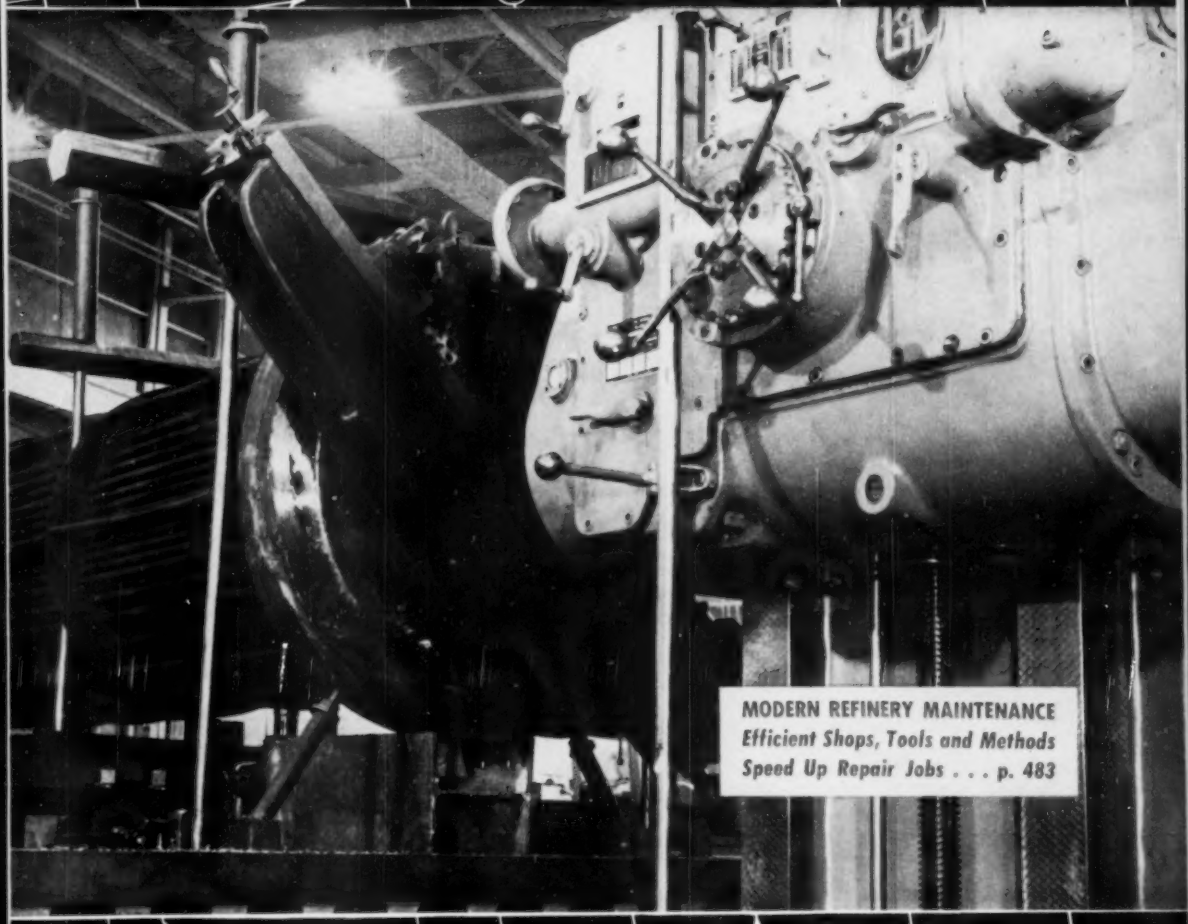
MAY, 1950
VOL. 5, NO. 5

PETROLEUM PROCESSING



MODERN REFINERY MAINTENANCE
Efficient Shops, Tools and Methods Speed Up Repair Jobs . . . *p. 483*

13 in '49

THIS PLANT OF *Carthage Corporation,*

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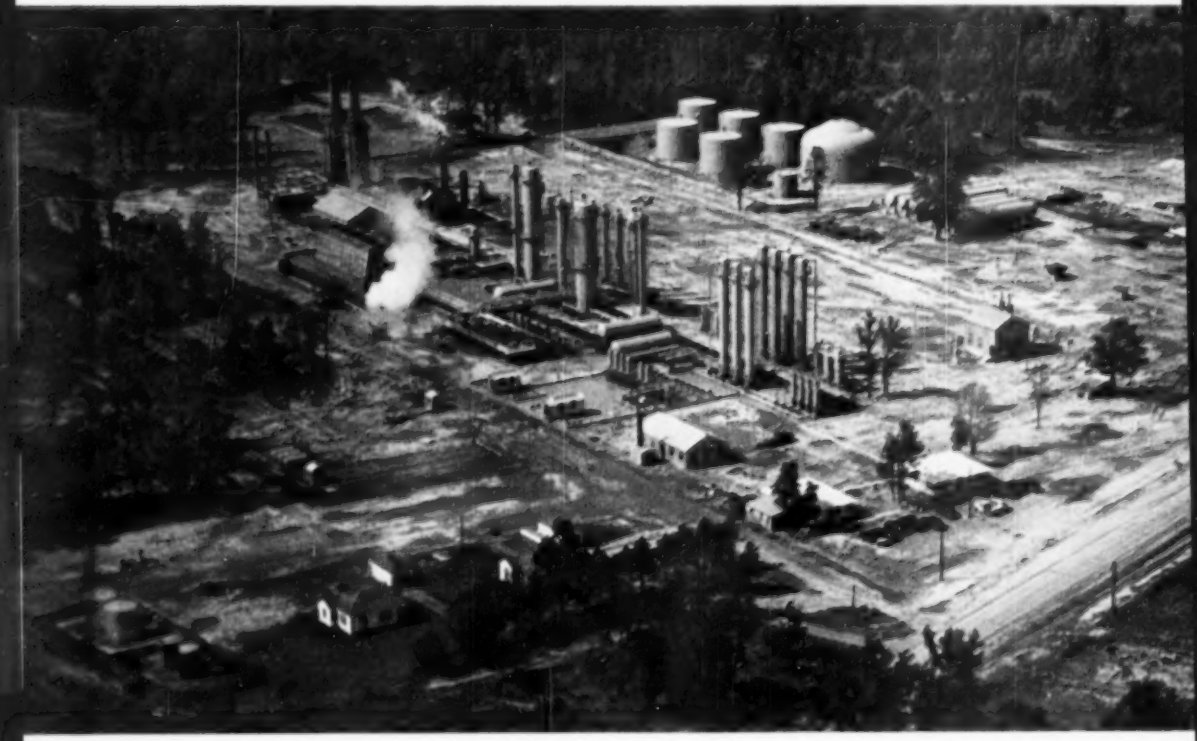

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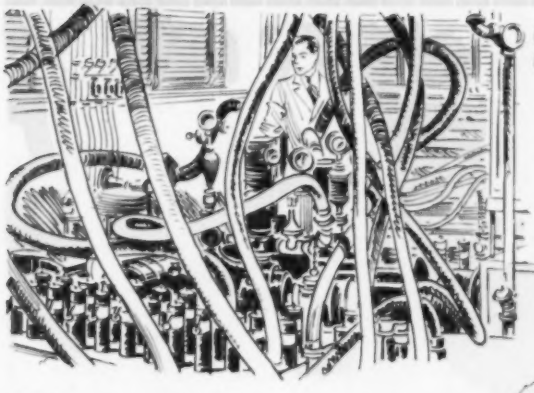
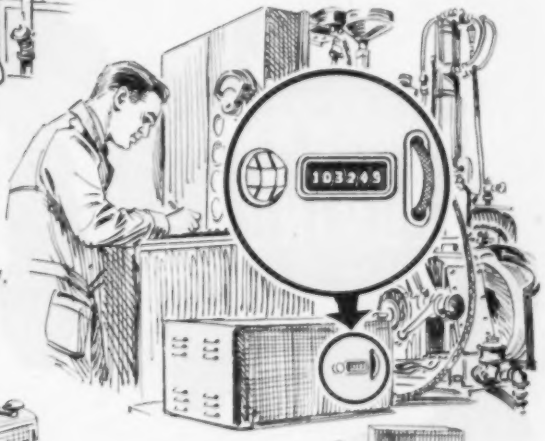
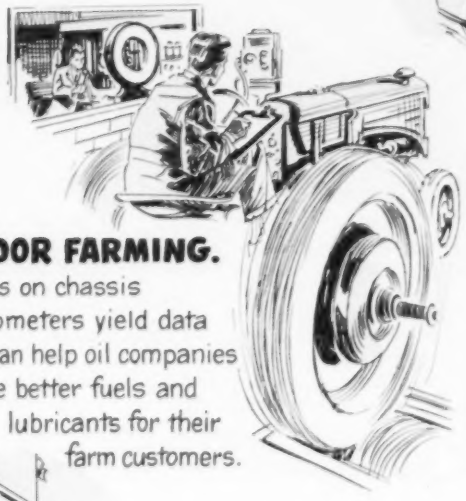
Speaking of Research... by ETHYL



SWITCHBOARD FOR FUELS enables Ethyl engineers to use 32 different fuels simultaneously in dynamometer research on engines. Information secured in these tests and others supplements research of individual refiners.



"WILD PING" is a fuel-engine problem under investigation. This electronic counter automatically totals the number of "wild pings" which occur intermittently.



INDOOR FARMING. Tractors on chassis dynamometers yield data which can help oil companies produce better fuels and lubricants for their farm customers.

HAVE A PROBLEM? Information from 27 years of fuel-engine research is on file at the Ethyl Laboratories ...and is available to refiners.

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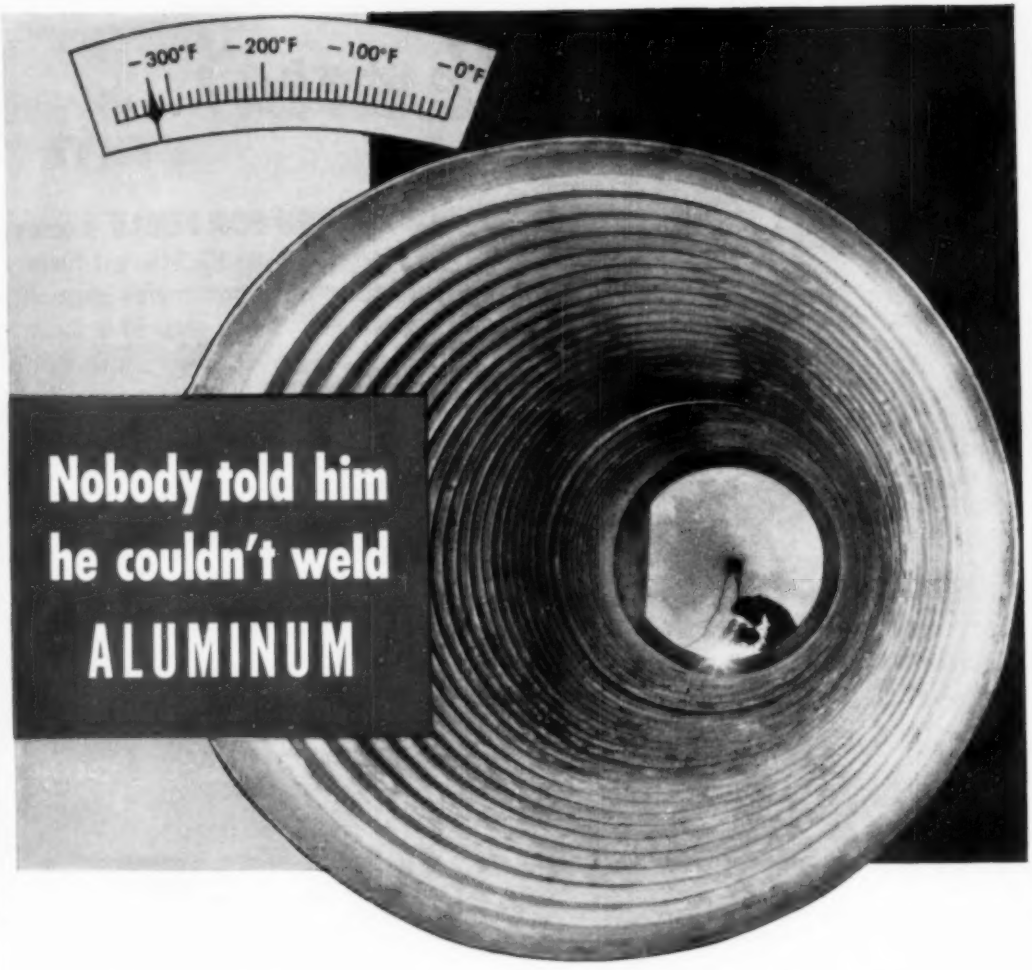

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(To obtain more data on advertised products see page 536)

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Published second Tuesday of each month by National Petroleum Publishing Co., 1213 West Third St., Cleveland 13, Ohio. Subscriptions: $3.00 a year in U.S. and possessions, $3.50 a year elsewhere. Single copies, 35 cents each; back copies more than three months old, 50 cents each. Published prior to Sept., 1946, as the *Technical Section of National Petroleum News*, devoted to Refinery Management and Petroleum Chemical Technology, and including *International Petroleum Technology*. Trade mark registered U.S. Patent Office. Copyright 1950 by National Petroleum Publishing Co. Acceptance under the act of June 5, 1934, at Cleveland, Ohio, authorized Dec. 22, 1948.

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PLATT'S OILGRAM NEWS
A daily independent oil-news reporting service issued from New York, Cleveland, Houston

NATIONAL PETROLEUM NEWS
The weekly oil marketing magazine, covering news, prices, transportation, storage, merchandising

PLATT'S OILGRAM PRICES
A daily independent oil-price reporting service issued from New York, Cleveland, Houston

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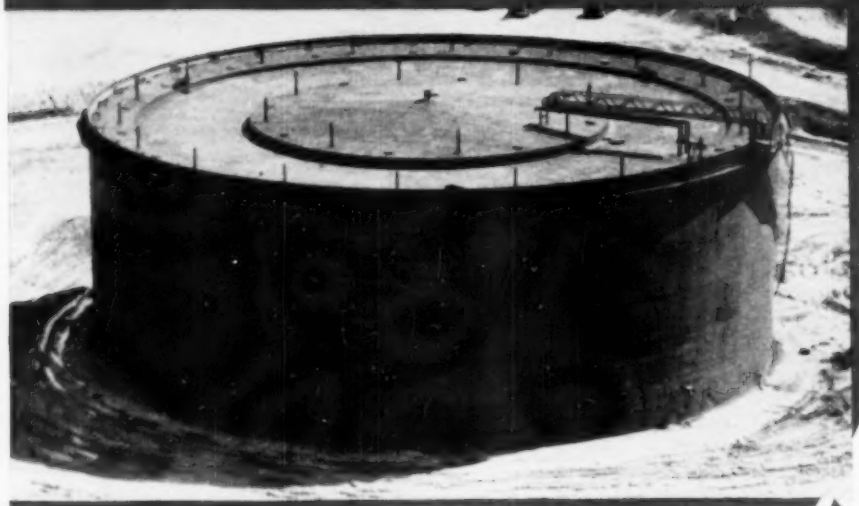
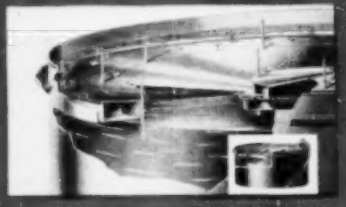
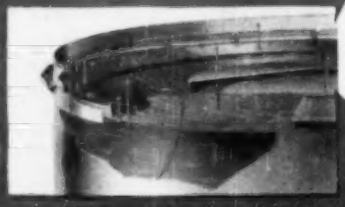


Floats on the liquid and seals the liquid surface with the aid of a vapor-tight closure. Rises and falls with changes in volume. Permits vapors to expand without venting. Prevents losses during refining, transportation and marketing. Saves vapors when unreasonable crudes and products are stored.

Only genuine Wiggins Floating Roofs give you triple seal protection! 75% of "full tank" evaporation losses are eliminated. Retains 95% of the vapors lost by tanks with only single seals. Has the much-copied Wiggins lumber shoe ring sealed by John H. Wiggins' exclusive pressure, contained contact with the tank shell. Very few maintenance costs—deep deck assures rapid drainage.





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The economical way to conserve the vapors of a single tank or two interconnected cone roof tanks. The roof is supported by confined vapor, rising and falling as the volume changes. Has a patented dry seal to prevent vapor from escaping. Internal pressure exceeding 1¼" of water causes roof to lift. Maximum roof lift is 10 feet. Balancing system keeps roof level even under eccentric load conditions produced by wind or snow.

Wiggins
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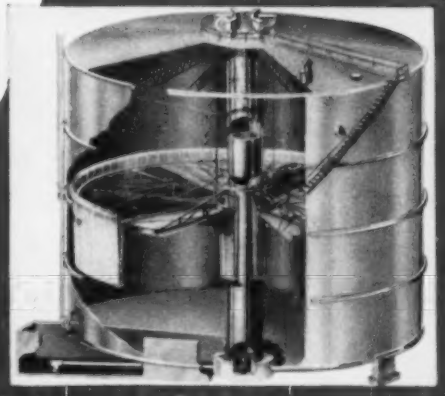
GASHOLDER
Typical Average Pay-Out
20 MONTHS



Wiggins Dry Seal Gasholder operates at standard working pressure with all cone roof tanks for a complete vapor conserving system.

Turns breathing and pumping losses into profits! The 100% dry seal, which has a life equal to that of the tank, eliminates "wet seal" corrosion problems—requires no heating system during freezing weather. No fire hazard. Has low initial cost—low upkeep. Attention, adjustment or lubrication not needed.

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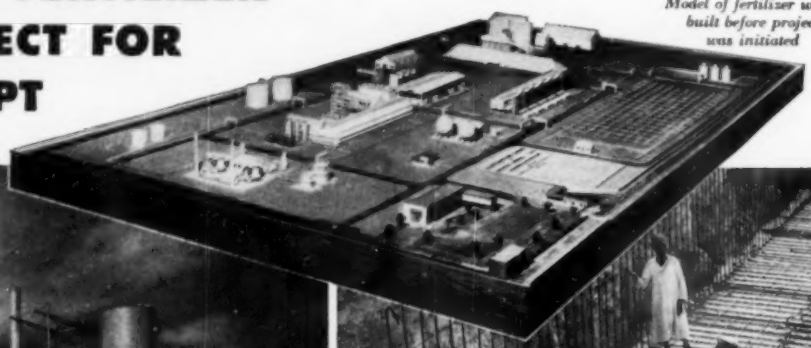
Progress Report by Chemico

LARGE FERTILIZER PROJECT FOR EGYPT

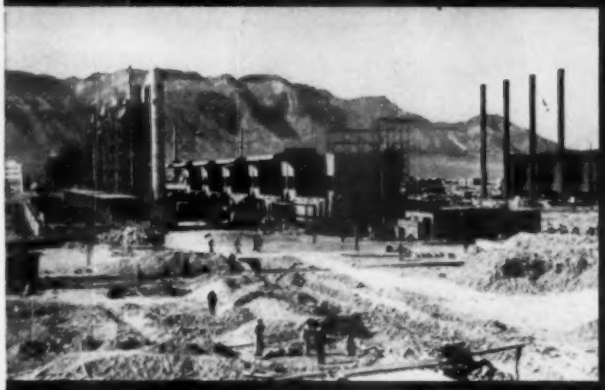


Model of fertilizer works built before project was initiated

Gas reformers to convert refinery gas to hydrogen and nitrogen

Local craftsmen placing reinforcing steel for foundations

Nitric acid absorption towers and ammonia storage tanks



General view of the project which covers an area of 1350 acres

These photographs show work in progress on the 550-ton per day fertilizer plant being built at Suez, Egypt. This important Chemico project includes plants for the production of synthetic ammonia, nitric acid and calcium nitrate together with complete facilities for supplying utilities such as power and water to the various units. This is one of a number of world-wide Chemico activities which include projects in Formosa, India, Mexico, South Africa and Brazil. Whatever your problem may be in the production of heavy chemicals ... wherever it may be ... you can be sure that Chemico will deliver a highly efficient plant on a guaranteed-performance basis.

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C-2 '57

What's Happening!

Important Current News Summarized for Refiners

EXPANSION

Pennzoil Co. will build a 1370 b/d propane-deresining and resin-fractionating unit at its Rouseville, Pa., lube plant. Unit is being designed and built by M. W. Kellogg Co., and completion is scheduled for late 1950.

Pan-Am Southern will build a second Fluid cracking unit of 9000 b/d gas oil capacity with associated vapor recovery unit at its El Dorado, Ark., refinery. Contract has been awarded to Foster Wheeler Corp., with completion expected within 12 months. These facilities, with coking unit now under construction, will boost plant crude capacity about 20%, or to 30,000 b/d, and permit production of 16,500 b/d of gasoline. Coker, being built by Lummus Co., is about 35% complete with finish scheduled in September.

California Refining Co. has awarded a contract to Catalytic Construction Co. for the construction of three gasoline treating units at its Barber, N. J., refinery, with completion scheduled for August. Construction will begin immediately on two lead sulfide sweetening plants and a reagent plant, each with 10,000 b/d capacity.

Kendall Refining Co. has contracted with Universal Oil Products Co. for a 1,500 b/d Platforming unit, to be erected at its 5,000 b/d refinery at Bradford, Pa. Contract covers design, engineering and erection.

• • •

SYNTHETICS

Interior Department sharply denied last month charges voiced in the Mar. 20 *Christian Science Monitor* that Interior is thwarting development of an economical process for converting coal to oil. The process in question is one developed by Lewis C. Karrick, former fuels expert with Interior's Bureau of Mines, and is described by the Bureau as "one of the least efficient and most obsolete of the many variations of low-temperature carbonization."

Basic cost figures for producing synthetic liquid fuels from coal and oil shale are to be developed by the American Petroleum Institute's refining committee as an answer to recent claims made by the government's Bureau of Mines. Agreement to make study was reached by the API board of directors April 3 during its meeting in Houston, and followed recommendation contained in an editorial published in the March 22 issue of *National Petroleum News* and April issue of PETROLEUM PROCESSING. Although there was no formal vote on the matter by the API board, consensus was that the time had arrived for industry "to break out and publicize the real honest-to-God basic costs" of producing synthetics. Bureau has claimed that cost of producing synthetic fuels from some sources today is practically competitive with cost of fuels from crude.

• • •

FOREIGN

Societe Industrielle Belge des Petroles is building a complete 30,000 b/d refinery at Antwerp, Belgium, with construction now under way, and with completion scheduled for mid-1951. No information has been released on type of units being installed, except that the refinery "will utilize normal refining processes" and that "sufficient space has been provided for the future addition of process units to produce additional products, such as lubricating oils and high octane gasoline." Contractor is M. W. Kellogg, and its European subsidiary—Kellogg International Corp.

• • •

NATURAL GASOLINE

Superior Oil Co. will build a $1.5 million natural gasoline plant in the Altair field, Colorado Co., Texas, to handle between 50,000 and 70,000 Mcfd. of gas—if Federal Power Commission OK's a plan to sell the residue gas.

Proration of all hydrocarbons on an equal basis has been urged by the Independent Refiners Assn. of America to conform with market demand and "treat fairly" all segments of the oil industry. Texas Railroad Commission called a special hearing on the request last month, and then deferred it until Commissioner Olin Culbertson, ill from a heart attack, can resume his duties.

Benedum natural gasoline plant near Rankin, Upton Co., Texas, owned jointly by Texas Natural Gasoline Corp. and Upton Gas Products Co. and operated by the former, has been completed. Plant capacity is 55,000 Mcfd. with recovery of 155,000 gal. daily of propane and butane and 40,000 gal. day of Grade 26-70 natural

Information on these pages is obtained through the nation-wide news coverage service of PLATT'S OILGRAM NEWS

gasoline. Residue gas is sold to El Paso Natural Gas Co.

Expansion of the Rincon natural gasoline plant near McAllen, Texas, operated by Continental Oil Co., has been completed. Capacity has been increased from 13,000 to 20,000 Mcfd. of gas at cost of $1.3 million; plant now produces daily 16,000 gal. propane and butane, plus 25,000 gal. natural gasoline. Residue gas is sold after returning about 8,500 Mcfd. of gas to the five main producing reservoirs.

Levelland (Texas) natural gasoline plant, to be operated by Stanolind Oil & Gas Co. for the 10 other owners, was dedicated April 29. Capacity is 40,000 Mcfd. of gas with daily production of 130,000 gal. of liquids, including 60,000 gal. of 12-lb. natural gasoline, 30,000 gal. propane and 40,000 gal. butane.

• • •

MARKETS, PRICES

Refinery prices appeared to have "bottomed out" in April, and started upward for a long list of products. Heavy drafts continued on the nation's inventories of light and heavy fuel oils, and gasoline stocks turned downward as spring demand set in. The result was a general strengthening in crude oil prices in Mid-Continent and Southwestern producing districts. In California, demand for product also pointed upward, and the surplus of residual in that area was whittled down by additional purchases of fuel oil by East Coast cargo buyer. There was some seasonal easing in distillate prices, but the trend for most others was upward.

Gasoline prices were advanced at the wholesale level by Esso Standard, Socony-Vacuum and Atlantic Refining, in amounts ranging from 0.5 to 0.9c per gal. at most points along the middle Atlantic and New England coast. Prices for cargo lots of gasoline at the Gulf were up in amounts ranging from 0.25 to 0.375c per gal. Natural gasoline prices, FOB Group 3 and Breckenridge, Tex., were advanced a total of 0.5c per gal.

Bunker "C" fuel oil prices of Esso Standard were advanced 15c per bbl. at points in the East and at the Gulf, and this touched off a general increase in seaboard heavy fuel prices. Demand for heavy fuel oil in most areas showed few signs of an early let-up despite settlement of the coal strike and warmer weather. Heavy fuel for cargo lifting was offered sparingly at the Gulf.

Crude oil markets in general were firm, with only minor developments. Rock Island Oil & Refining Co. made advances averaging 8c per bbl. for low gravity crudes in Oklahoma, April 12. Imperial Oil Co., Ltd. advanced by 5c per bbl. to $3.50 its price for crude produced in the Glencoe and Bothwell fields of Ontario. In Mississippi, Gulf Refining Co. cut its price for the low-gravity Baxterville crude 30c per bbl. to $1.15, effective May 1.

Lubricating oil and wax trading was inactive, and prices showed little tendency to rise. Pennsylvania grade oils generally were off 0.5c per gal., and bright stock, 25 P.T., was offered at 16.5c.

• • •

PETROCHEMICALS

Synthetic benzene from petroleum is now being produced commercially by Pan American Refining Corp. at its Texas City, Texas, plant. Full commercial production started last December, but the company made no announcement of its successful venture until April 15. Process employed involves dehydrogenation of cyclohexane, and the isomerization and dehydrogenation of methylcyclopentane. Existing facilities at Texas City are estimated to be capable of manufacturing between three and five million gallons of 1° benzene a year.

Mathieson Hydrocarbon Chemical Corp. plans a new $17,000,000 plant near Brandenburg, Ky., on the Ohio river, to process natural gas hydrocarbons into chemicals. The new company is a joint venture of Mathieson Chemical Corp. and the shareholders of Tennessee Gas Transmission Co. Latter firm will supply the raw materials, from a $12,000,000 absorption plant to be built adjacent to its gas pipe line near Greensburg, Ky. An 8-in. line will move the separated ethane, propane, butane and natural gasoline from Greensburg to Brandenburg. Mathieson has acquired over 2000 acres of land for its plant, which it expects to have completed by the end of 1951.

• • •

PRODUCTS

A new military specification for heavy-duty engine oils was announced for the first time last month by R. E. Streets of the Ordnance Office. The new specification, MIL 2104, is expected to supercede the present 2-104B specification by not later than June 1951. Principal difference is in the fuel used in the L-1 engine test procedure, which will be required to have a 0.35% minimum natural sulfur content; the present 2-104B specifies only a maximum sulfur content of 0.4% in the test fuel, and no minimum.

Sun Oil Co. is now for the first time in its history marketing leaded motor fuel. Previously the company depended entirely upon processing operations (primarily catalytic cracking) to attain the necessary quality level. It will continue, however, to adhere to the policy of marketing only one grade of gasoline, under the name "New Blue Sunoco."

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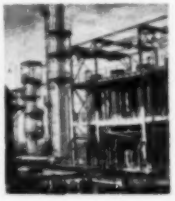
A strange breed of "cat" ... cat-equipment, that is!

ONE of the unusual types of equipment Kellogg is frequently called upon to fabricate is the cat-poly reactor. A strange breed of heat exchanger, it is in reality a combination pressure vessel and heat exchanger, inasmuch as operating pressures in the catalyst-packed tubes reach 1200 psi. Another unusual aspect of these exchanger-vessels is that they are designed to be taken out of service regularly for replacement of catalyst, rather than being built to operate without maintenance for as long a period as possible.

Fabrication of this type of equipment is unusual, too, in the heat exchange field. First, it's on the "grand" scale, tubes being 5 inches in diameter and 40 feet long, and the shells 50 inches in diameter. But probably the most important single fabrication step is *the welding of the tubes to the tube sheets*, replacing the customary roll-in operation. Here Kellogg's unusually broad experience in welding techniques asserts its importance... guarantees the customer finished cat-poly reactors in the minimum time with the maximum service life built in.

One recent order!

An even dozen Kellogg cat-poly reactors are installed in this brand new East Coast refinery. Another three-quarter dozen are now being finished in Kellogg shops, destined for a Midwest plant operated by the same refiner.



Continuing Basic Study of the principles of heat exchange conducted by Kellogg development groups for more than twenty years has produced unduplicated design data.

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Tomorrow

. . . IN PETROLEUM TECHNOLOGY

By B. H. WEIL, Atlanta, Ga.
Editor, "Monthly Summary of Industrial Developments"

Brief Reviews of Current Technological and Economic Developments, Reported in the Light of Their Possible Effect on Future Petroleum Processing Operations

Knockless Gasoline Engines Are Under Development

BETWEEN laboratory experiments and commercial realities lie chasms of almost unknown depths. Many are the promising discoveries which "fail to make the grade"; research organizations know this full well and have long since developed the proper philosophy. Occasionally, however, a discovery is made which seems of unusual importance; then, the effort to carry it to fruition may exceed all bounds—whereupon the invention has a better mathematical chance of meeting with success.

Far too little has been published, as yet, to determine what the odds are in this case, but the recent announcement that at least two organizations are working on engines which "burn" gasoline without regard to octane number seems certain to attract snowballing attention unless some barricade of presently unknown engineering reality is interposed.

One of these above-mentioned organizations, The Texas Company, is reported[1] to have announced the development of a knockless TCP (Texaco Combustion Process) engine which bases its operation on injection of the air-fuel mixture with a "swirl" (turbulence) into the cylinder. So far, only a single-cylinder engine has been tested, but a multicylinder engine is now reportedly being planned.

In this knockless engine, by coordinating the rate of fuel injection with the rate of swirl, a combustible mixture is continuously formed and burned just down-stream from the injection point, in the vicinity of the spark plug. Combustion products are swept away. The engine operates at full load until the combustion products reach the injector. Compression ratios of 6:1 to 12:1 have been used in the experiments, and it is reported that the engine will burn any gasoline; n-heptane and iso-octane are among the fuels which burn with equal success. The power output is said to vary only with the heating value of the fuel, there being no fuel requirement limitations. Fuel-air ratios of 0.01 to 0.10 have been used experimentally—ratios too lean for Otto cycle spark to too rich for Diesel ignition.

This method is said to work similarly in Diesel engines, where again no fuel requirement limitations have so far been found. Even at present, it is stated that this engine appears competitive with present gasoline engines as regards power output. Should it prove commercially possible to manufacture these engines, their use would increase the motor fuel fraction from crude oil (gasoline plus Diesel oil) to 71%, as compared with 54% at present.

S. D. Heron and A. E. Felt of the Ethyl Corp. are said to have recently described similar engine experiments to the SAE.[2] According to these men also, imparting "swirl" or turbulence to the fuel mixture prevents knocking. Ethyl experiments have also been conducted only on single-cylinder engines, however. "In the presently reported work, turbulence has shown up as the most important source of mechanical octane numbers."

If this "discovery" is translated into reality, its effect on the petroleum refining industry would be almost incalculable. The "octane race" would be over—although some other fuel criterion would probably "take over" at a later date.

Benzene from Petroleum Becomes a Reality

EVER since toluene became a petroleum chemical—at least in large measure—users of benzene and petrochemical manufacturers alike have longed to add benzene to the list of similar products.

Benzene consumers desire this because this hydrocarbon has been in exceedingly short supply for several years, because of increasing demands which show every sign of possessing at least a minimum permanent rate of growth, plus recurrent shortages caused by strikes in the coal industry, which supplies the chief raw material; benzene, at present, is a by-product of coke manufacture and manufactured gas production. Petrochemical manufacturers, of course, are always on the outlook for new and profitable products.

As mentioned previously in this series, however, the outlook for the production of benzene from petroleum has not been particularly bright. Refining methods such as hydroforming yield much smaller percentages of benzene than they do toluene; highest yields even here are obtained from stocks which are lighter than those usually so processed in gasoline manufacture. Other petroleum processing methods also fail to produce benzene to a very appreciable extent. These facts, coupled with the important reality that by-product benzene, being a by-product, has peculiar economics of its own which, even today, have kept prices low, have so far served to keep petroleum benzene off the market except for dribblets from petroleum gas manufacture (i.e., the by-product from plants using this process).

According to *Chemical Industries*,[3] however, "the next two years are expected to see operation at the first commercial unit for the synthesis of benzene from petroleum. Identity of participants in the venture cannot yet be disclosed, but they include a major user of benzene for chemical synthesis and a petroleum refiner with facilities capable of ready adaption to aromatic hydrocarbon production. Plans are well beyond the exploratory stage. Financial participation by the chemical producer will probably take the form of long-term contracts for benzene purchase at a fixed price.

"But benzene from petroleum will not sell at the present price of 22 c/gal. Best estimates put the selling price of petroleum-based benzene at about 28-30c, indicating a 6-to-8c price spread between the synthetic and coal-tar material. Coal-tar benzene is produced at about 3 c/gal. away from Texas, the main consuming area. And Texas has plenty of petroleum. Thus, the actual price spread is only 3-5 c/gal."

According to this source, the reason why this spread is still not discouraging the reported project is the growing shortage of benzene, coupled with uncertainties in the supply because of strikes in the coal industry. The 1950 demand for benzene is expected to approximate 164,000,000 gals., compared with an estimated 141,000,000 gals. in 1949 and 163,000,000 gals. in 1948.

Since the above information was released, it has become public that benzene from petroleum is already a reality, it now being produced at the rate of 3,000,000-5,000,000 gals./year by the Pan American Refining Co. at Texas City, Texas. Moreover, the Shell Chemical Co. is also said to be beginning benzene production at Dominguez, Calif.

Pan American's benzene, produced

by hydroforming, is reported to be selling for 35-40c/gal., a level at which continued long-range production cannot necessarily be forecast, if and when the strike-caused shortage of benzene is overcome. However, Pan American is producing benzene only intermittently and can discontinue production without difficulty if necessary.

The demand for benzene for the production of nylon is not expected to decrease in 1950, although nylon will also be prepared to some extent from furfural, petroleum cyclohexane, and butadiene. Although benzene is actually converted into cyclohexane in the process of nylon manufacture, du Pont is expected to prefer benzene as the raw material because of the capital expenditure required for equipment to purify petroleum-derived cyclohexane.

Petroleum, by now the favored raw material for synthesis or extraction of aliphatic hydrocarbons, bids fair to be an increasingly popular source of their aromatic (cyclic) brothers. There comes a time, apparently, when by-product status becomes inadequate for many chemicals—at least by-product status based on one raw material, coal.

Increasing Attention Paid To Literature Research

ONE of the axioms of the American Chemical Society's new Division of Chemical Literature is that more than half of the volunteers for work on any division program or endeavor are always petroleum information technologists or special librarians from petroleum companies. This speaks very well for the petroleum industry, for it proves again that petroleum companies have long been aware of the need for background information to guide their research, and current information to keep it abreast of developments, also that these companies have created groups which contain some of the leaders in the field of chemical (and other) information.

That literature searching is becoming increasingly complex can easily be judged by listening to symposia of the Division of Chemical Literature, but it is an interesting and important fact that this division and its programs are still intended to provide the chemist who must use the literature with the latest methods for such use, and not just to serve as a technical "bull session" for information technologists. The latter know full well that it is their special function to serve as guides and interpreters, and not to separate the scientist and engineer from his basic sources of information. Such service, however, *does* require special skills and training, but as Dr. J. W. Perry of the Massachusetts Institute of Technology has put it: "The chemical literature technologist is first a chemist and only secondly a literature researcher," so that it is not hard to see why the top men in this field are able to keep their companies' information programs in careful balance.

Petroleum literature research is no more static than petroleum refining itself. Use of new tools and the beginnings of cooperative effort give every indication that increased information services will be made available.

New Treatments and Uses Found for Synthetic Fibers

CHEMICALS from petroleum, to be of economic significance, must have commercial uses, either directly—solvents, plasticizers, and the like—or chemical intermediates for further synthesis. Among the growing fields which employ petrochemicals as some of their basic materials, none has lately been so active and challenging as that of the synthetic fibers—nylon, orlon, vinyon, saran, and, of course, rayon.

The synthetic fibers cannot always be substituted directly without applied research, however. For example, dyeing difficulties confront the rug manufacturer who desires to use nylon or orlon. Moreover, where price is not the chief consideration, it is sometimes possible chemically to treat natural fibers in such a manner as to overcome many of the advantages of the synthetics.

Nevertheless, the synthetic fibers continue to gain, for they, too, can be chemically treated to advantage where necessary. Nylon, for example, benefits materially from chemical treatment when used in the stapled form for spinning on "cotton system" machinery. More recently, the Deering-Milliken Co., a large fabric manufacturer, has announced[4] a new method of textile finishing which produces a metallized cloth which has many of the properties of wool.

This latter process is said "to increase the warmth of all currently-used clothing fabrics without increasing the weight or bulk of the cloth. The new method, as yet unnamed, calls for metallizing the back of the cloth by moistening it with a liquid solution of aluminum treated with stearic acid. This metallic liquid forms scales on the fabric roughly similar to those naturally found in wool fibers. . . .

"Deering-Milliken maintains that the metallic-scale on cloth forms a better reflector than the natural wool scale." In one test, "a piece of processed rayon had a warmth equivalent to a piece of wool ten times as thick. . . . A processing plant is being constructed in S. C. that is expected to be in operation at full capacity at the end of the year. . . . Retail costs of garments using the new processed fabric should not be increased by more than $1 or $2, if at all.

"Initially, the process will be used on fabrics to be employed in the manufacture of coats, suits, bed coverings, gloves, ear muffs, and knitting yarns. . . . The testing of processed cloth indicates that washing or dry cleaning cause only a minute loss, no more than 3% of its warmth property. It is unaffected by waterproofing or other finishing treatments. However, it cannot be applied to rubberized fabrics."

The synthetic fibers seem destined to play an increasingly important role in the textile industry. As their use increases, so will the consumption of chemicals from petroleum used in their manufacture.

New Type of Hard Carbon Obtained from Natural Gas

THE petroleum and natural gas industries have long since recognized that carbon black, petroleum coke, lampblack, and similar forms of carbons are among the most useful by-products and derivatives which they produce, but it comes as somewhat of a surprise to learn that a synthetic graphite-like coke produced from natural gas may be added to this list of industrial carbons.

According to a recent announcement,[5] however, Godfrey L. Cabot, Inc., has begun "semi-commercial production of a brand-new form of carbon from natural gas. Unlike carbon black, which is the fine, soft soot deposited by a smoky gas flame, the new material is produced directly in the form of solid, hard bead about a sixteenth of an inch in diameter. Because of its resemblance in structure to coke, the product has been named gas coke. . . .

"Cabot officials are at present revealing no more about the process than to say that adaptation of existing black plants, either furnace or channel, to production of the new material is not practicable." The material is said to have potential uses as a substitute for retort carbon in electrical uses, as a carburizer for the metallurgical industries, etc. "But the real selling point of gas coke is that there is no limit to the potential supply, while graphite is where you find it. Between 60 and 80% of our graphite requirements today are imported, principally from Mexico."

References

(1) George Weber, "Revolutionary Engine," *Oil and Gas Journal*, 48, no. 43, 21 (1950).
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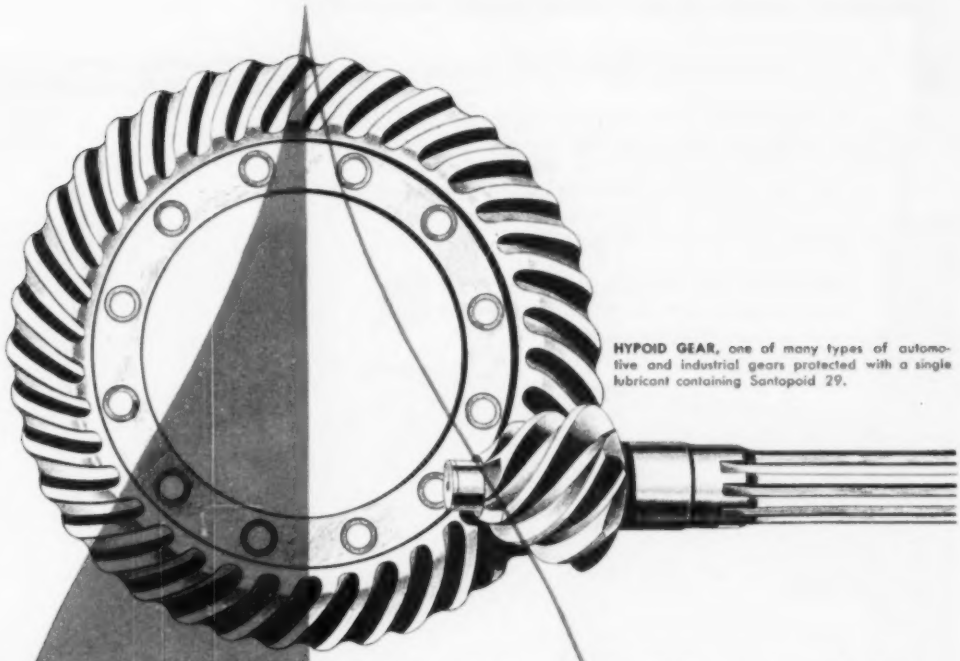

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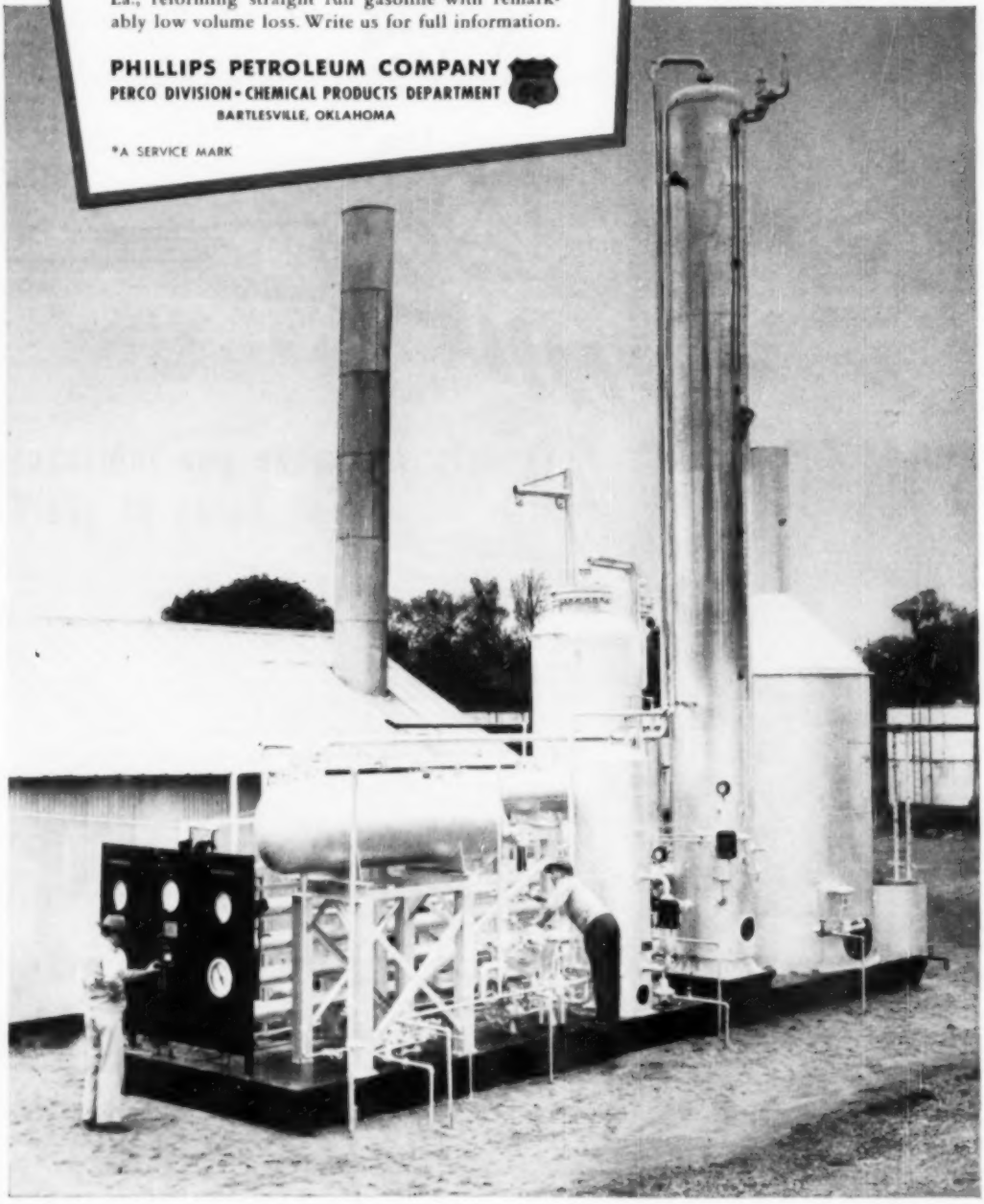

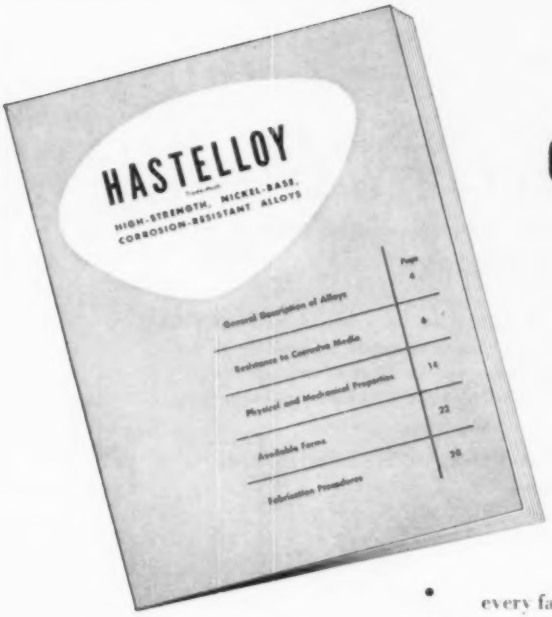

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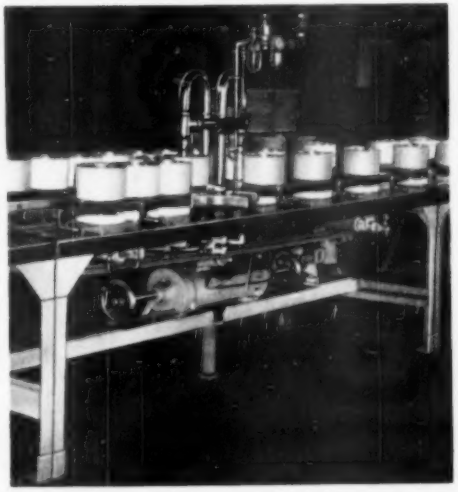

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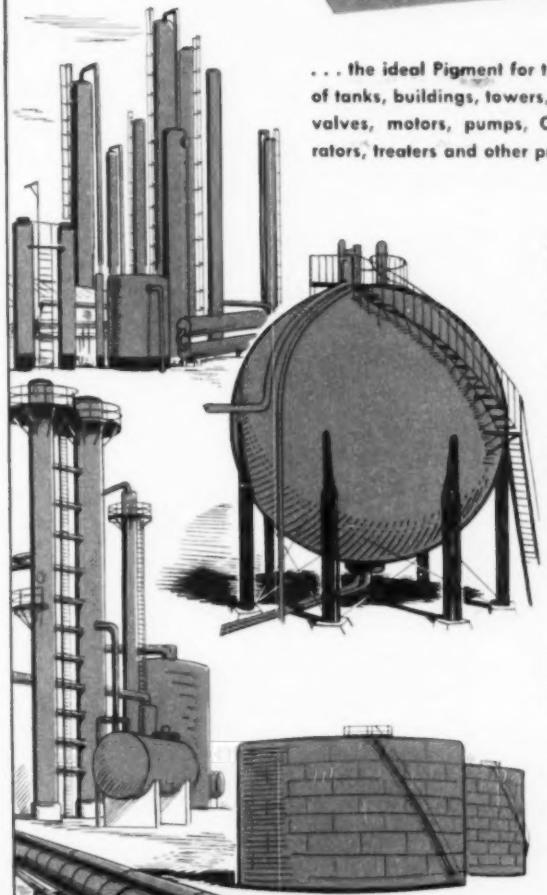

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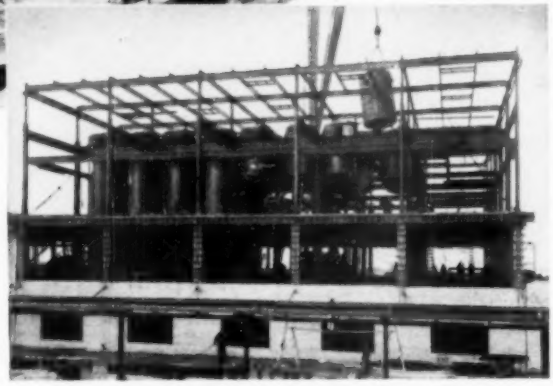

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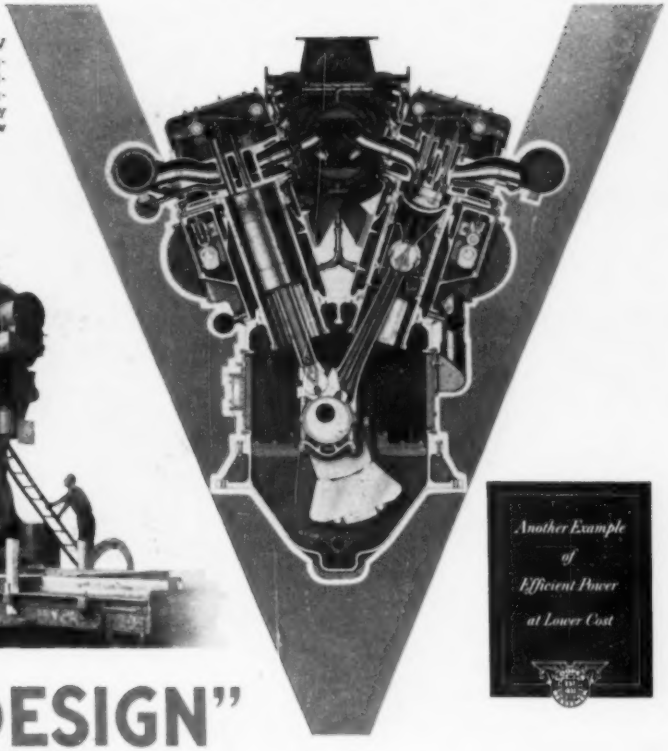
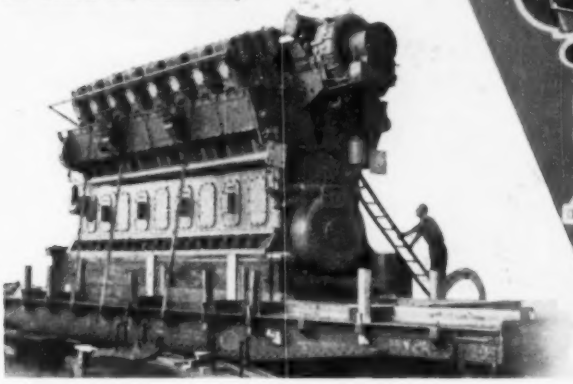
BELOW: Cooper-Bessemer 16-cylinder LSV engine, rated 3,400 hp at 327 rpm, mounted on flat car ready for shipment. As shown, complete factory-tested engine can be shipped as a unit without any disassembly.





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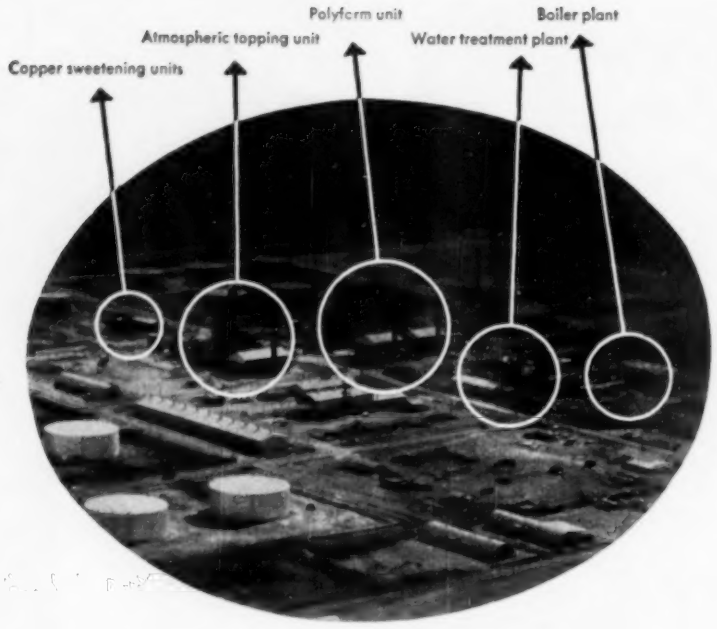

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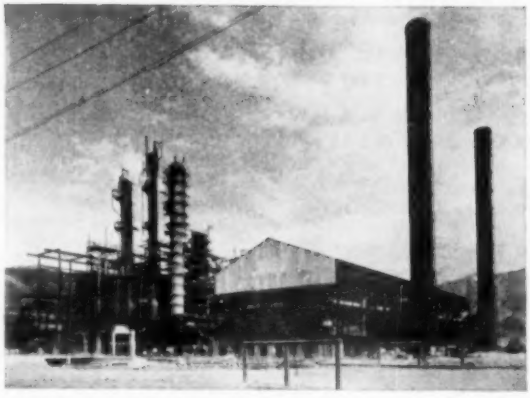

Naphtha-gas oil polyform unit. The gas oil is cracked once-through in the presence of propanes and butanes in a Lummus heater. Naphtha with propanes—butanes is cracked in the same furnace.

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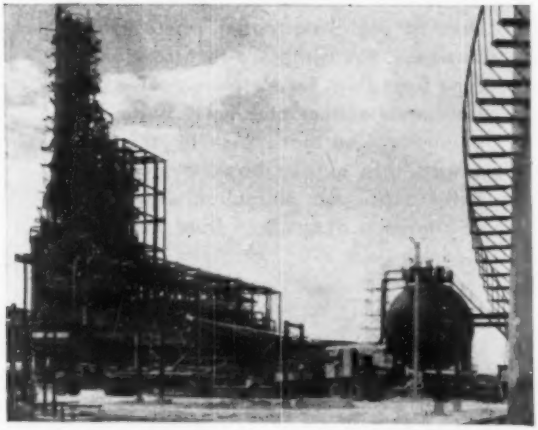

Atmospheric topping unit, with 34-foot settling sphere of desalting unit at right. The gas recovery system consists of a compression recontacting operation followed by depropanization. The topping unit is equipped with a single down-draft Lummus furnace.

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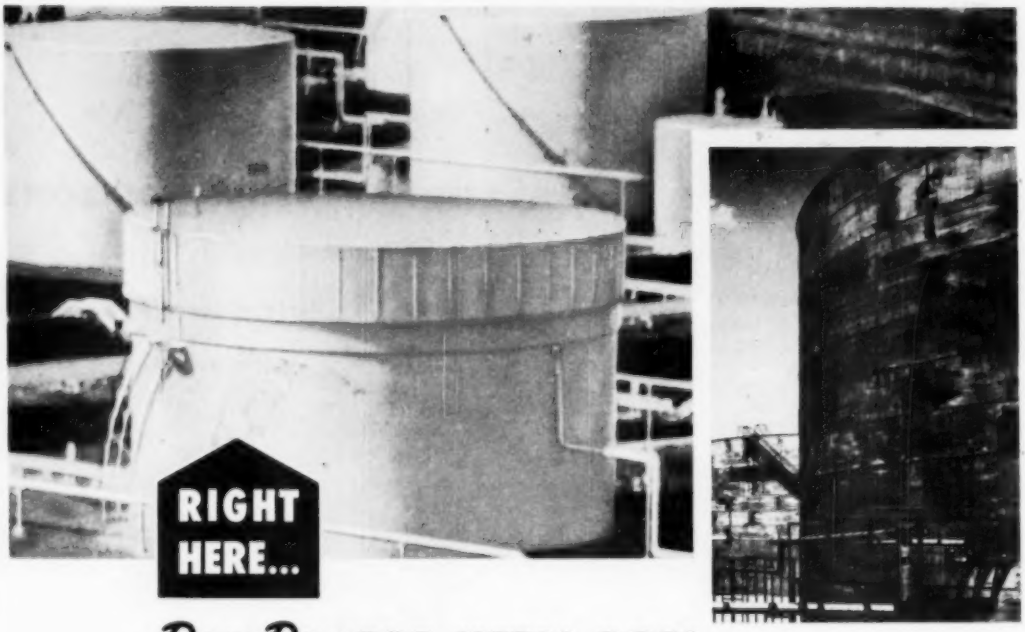
Esquina Las Gradillas, Caracas, Venezuela



Dum Dum FOR METAL DOES WHAT PAINT CAN NEVER DO!

This thick, tough, elastic coating (not a paint) stands up against every kind of corrosive element; combats industrial fumes and gases, sun and rain, freeze and thaw for years and years. It does what even the best of metal protective paints (which we make, of course) can never do.

Can you afford to paint?

If you buy materials with an eye on length of service, you can't afford to take chances with temporary protection. Not when Dum Dum for Metal gives more lasting protection over the long haul than any other protective coating.

See for yourself!

You'll find experienced appliers of Dum Dum for Metal no matter where you do business. For complete information on how Dum Dum for Metal can solve your tank maintenance problem... write, wire or phone Arco today. Ask for the interesting, informative booklet, available without charge or obligation, which gives all the facts about Dum Dum for Metal. Address Dept. P-5.

"Dum Dum" is a registered trademark of The Arco Company.

Dum Dum FOR METAL'S MANY ADVANTAGES

MORE THAN A PAINT—Dum Dum for Metal is spray applied in a thick, tough but elastic coating many times the thickness of paint. It adheres to metal surfaces regardless of shape or contour.

NO MOISTURE SEEPAGE... NO MOISTURE VAPOR TRANSMISSION—Most paint films become porous in time and allow direct seepage of moisture. Dum Dum for Metal sets up a "vapor barrier"... keeps out not only moisture, but also *moisture vapor*.

STAYS PLIABLE—Dum Dum for Metal's outer surface sets up with a tough skin while the undersurface remains pliable and elastic.

HEALS ITSELF—Should Dum Dum for Metal's tough outer surface be bruised or broken, the pliable undersurface skins over where exposed and heals itself.

ARCO
SINCE 1881

Paints, Lacquers, Varnishes, Enamels, Protective Coatings

TRADE MARK

TESTED FIRST TO MAKE IT LAST!

THE ARCO COMPANY • CLEVELAND • LOS ANGELES

[*To obtain more data on advertised products see page* 536]

HERE'S WHAT THE KEY IN OUR TRADE-MARK MEANS

ARTHUR G. McKEE & COMPANY offer many engineering services to petroleum refiners—but only *one* standard of engineering.

That single standard of quality has always been the key to McKee success in the design, engineering and construction of petroleum processing facilities in all quarters of the globe.

McKee policy requires that we execute every project to the best of our ability, at the lowest possible cost *consistent with correct design, thorough engineering and sound construction.*

ARTHUR G. McKEE & COMPANY

DESIGN, ENGINEERING AND CONSTRUCTION FOR THE PETROLEUM REFINING AND IRON AND STEEL INDUSTRIES

ENGINEERS AND CONTRACTORS • ESTABLISHED 1905
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facts about treating?

FACT 1 Mercaptan *removal* is today's answer to deodorization problems.

FACT 2 Modernizing with the *Tannin Solutizer Process* for mercaptan removal yields "new refinery" economies in treating and blending your finished leaded gasoline.

FACT 3 *Conversion and operating costs* are extremely low.

FACT 4 The Tannin Solutizer Process is not *corrosive*.

FACT 5 The high efficiency of the Tannin Solutizer Process has been conclusively demonstrated during more than *five years* of commercial refinery operation.

FACT 6 The Tannin Solutizer Process does not affect the *stability* of the gasoline treated.

FACT 7 Complete Tannin Solutizer *process engineering* service is available—during the planning of your unit, at start-up, and thereafter if required.

We will welcome the opportunity to work with you on your specific problem. The Tannin Solutizer Process is licensed under the patent rights of Socony-Vacuum Oil Company and Shell Development Company.

SHELL DEVELOPMENT COMPANY

50 West 50th Street, New York 20, New York

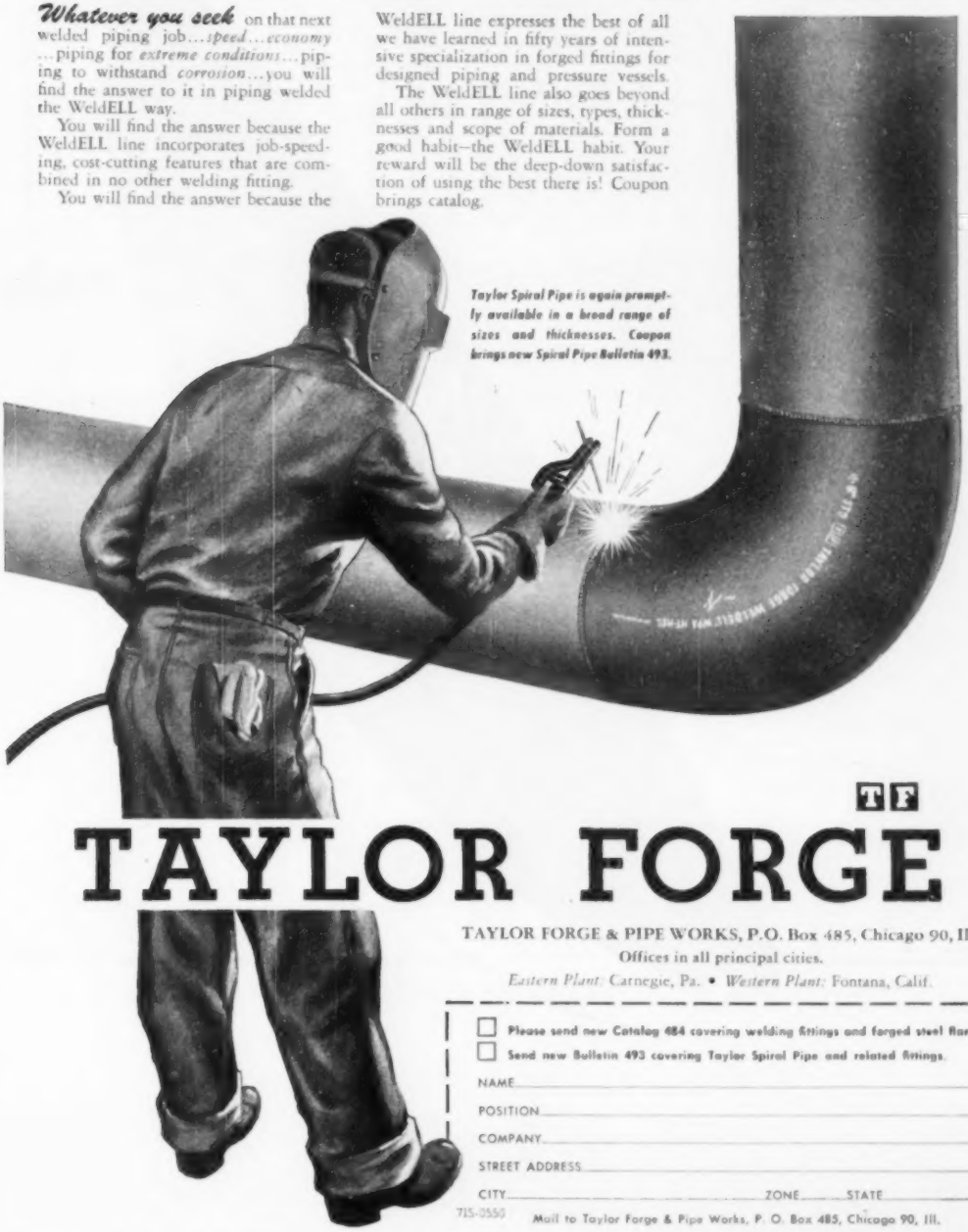
WeldELLS®

Whatever you seek on that next welded piping job...*speed*...*economy*...piping for *extreme conditions*...piping to withstand *corrosion*...you will find the answer to it in piping welded the WeldELL way.

You will find the answer because the WeldELL line incorporates job-speeding, cost-cutting features that are combined in no other welding fitting.

You will find the answer because the WeldELL line expresses the best of all we have learned in fifty years of intensive specialization in forged fittings for designed piping and pressure vessels.

The WeldELL line also goes beyond all others in range of sizes, types, thicknesses and scope of materials. Form a good habit—the WeldELL habit. Your reward will be the deep-down satisfaction of using the best there is! Coupon brings catalog.



Taylor Spiral Pipe is again promptly available in a broad range of sizes and thicknesses. Coupon brings new Spiral Pipe Bulletin 493.

TF

TAYLOR FORGE

TAYLOR FORGE & PIPE WORKS, P.O. Box 485, Chicago 90, Ill.

Offices in all principal cities.

Eastern Plant: Carnegie, Pa. • *Western Plant:* Fontana, Calif.

☐ Please send new Catalog 484 covering welding fittings and forged steel flanges.

☐ Send new Bulletin 493 covering Taylor Spiral Pipe and related fittings.

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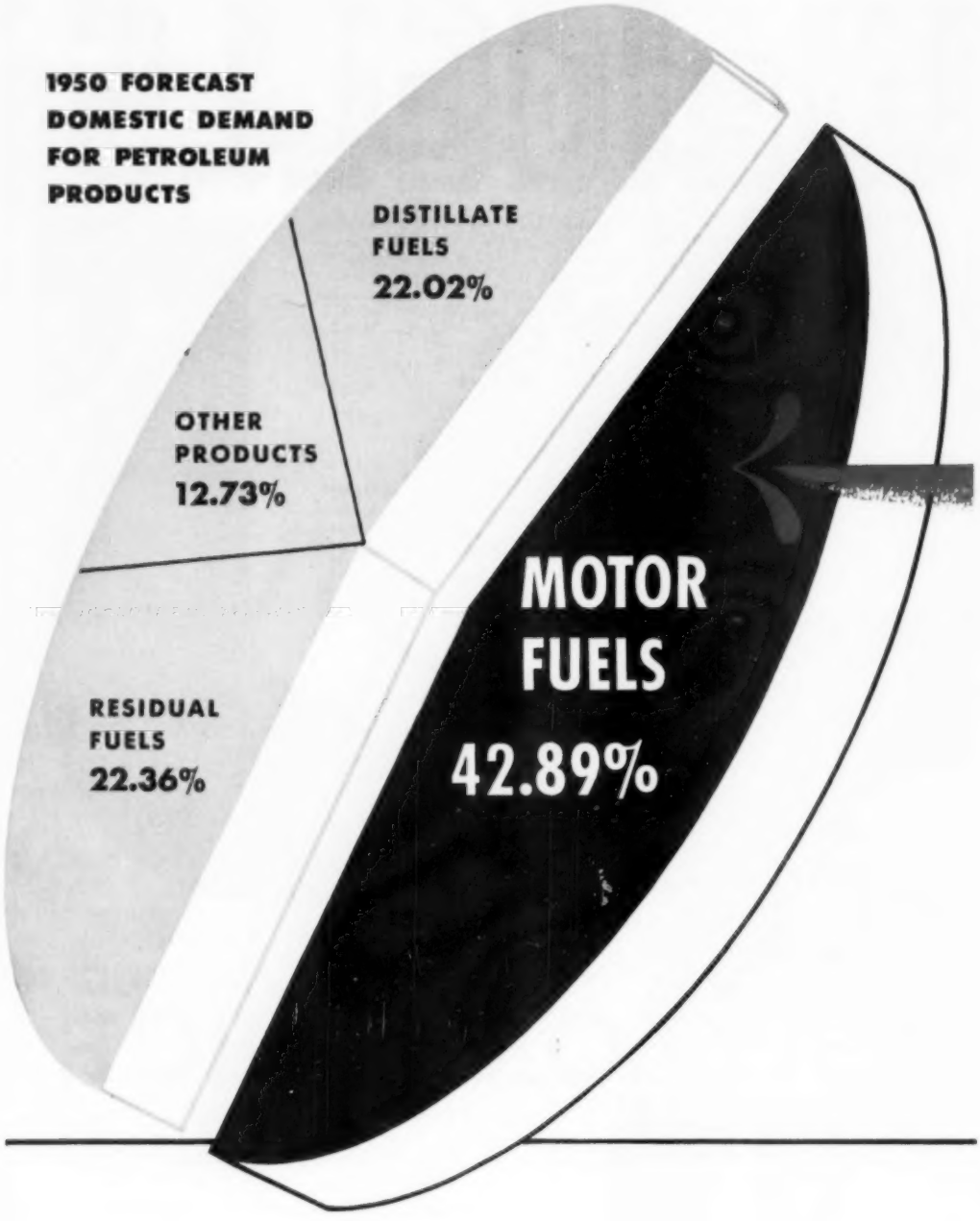
Mail to Taylor Forge & Pipe Works, P. O. Box 485, Chicago 90, Ill.


1950 FORECAST
DOMESTIC DEMAND
FOR PETROLEUM
PRODUCTS
DISTILLATE
FUELS
22.02%
OTHER
PRODUCTS
12.73%
RESIDUAL
FUELS
22.36%
MOTOR
FUELS
42.89%

here's the market

FOR THE 11,640,000 GALLONS OF NATURAL AND RECYCLE GASOLINES THAT WILL BE PRODUCED EACH DAY IN 1950

More natural gas, more natural gasoline. At the same time, motor fuels are accounting for a greater and greater percentage of the overall demand for petroleum products. But how do you fit the increased amounts of finished gasoline and naphtha from your natural gasoline and recycling operations to this market when the demand is for products of higher and higher quality?

This is the answer: Up-grade these low research octane products with UOP's Platforming process . . . produce Platformate . . . and you have a motor fuel that meets *any* market requirement. No other process can up-grade low quality stocks as efficiently as Platforming. No other product has the high quality and superior performance of Platformate.

Platformates produced from natural gasoline and recycle naphthas have research and road-ratings of nearly 100 (with the addition of 3 cc. of lead). They are inherently stable and negligible in sulfur content. The odor is pleasant. There is more energy per gallon. And the Platforming process is economical . . . both in its initial investment and operating costs.

Investigate Platforming now. Up-grade your low quality natural gasoline and recycling products to a point where they meet any market requirement.

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PRODUCT OF THE PLATFORMING PROCESS, DEVELOPED AND LICENSED BY

UNIVERSAL OIL PRODUCTS COMPANY

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UOP

Laboratories:
RIVERSIDE, ILLINOIS

Universal Service Protects Your Refinery.

Stop VALVE SHOPPING!

for BRONZE — IRON — STEEL — CORROSION-RESISTING Valves

POWELL *makes them all*

Fig. 6061 — Class 600-pound Cast Steel Swing Check Valve. Flanged ends and bolted flanged cap.

When you want to buy a new suit, you don't shop for the coat in one place, the vest in another, and the trousers in still another.

But that's just what you do if you get your bronze or iron valves from one source, cast steel valves from another and possibly special design or alloy valves from several others.

No one makes better bronze, iron or steel valves than we do. And, in the field of special design and alloy valves for corrosion-resistance, Powell has always led the way. Today Powell makes the *only* COMPLETE line of these valves available.

In short, Powell makes all kinds of valves* needed in your industry—and makes them better. So stop shopping for valves. Standardize on Powell . . . and centralize responsibility for the efficient operation of the entire flow control system in your plant.

Fig. 6079 — Class 600-pound Cast Steel Gate Valve for Pipe Line Service. Has flanged ends and bolted flanged bonnet. Bevel gear operated. Also available in Classes 150, 300, and 400 pounds.

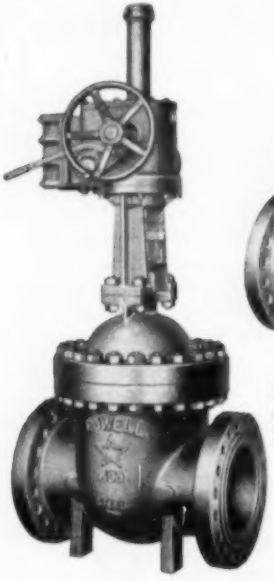


Fig. 6079 M.O. — Class 600-pound Cast Steel Gate Valve for Pipe Line Service. Has flanged ends and bolted flanged bonnet. Motor operated. Also available in Classes 150, 300, and 400 pounds.

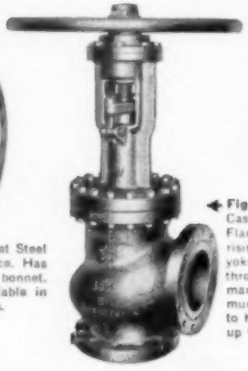


Fig. 1375—200-pound Bronze Gate Valve with screwed ends, inside screw rising stem, union bonnet and renewable, wear-resisting "Powellium" nickel-bronze seat rings and disc.

◄ Fig. 3033 — Class 300-pound Cast Alloy Steel Angle Valve. Flanged ends, outside screw rising stem, bolted flanged yoke. Streamlined areas through the body assure maximum flow with minimum pressure drop. Built to handle temperatures up to 1400F.

***The Complete Powell Line includes Globe, Angle, "Y", Gate, Check, Non-return, Relief, and Flush Bottom Tank Valves in Bronze, Iron, Steel and a wide range of Corrosion-resistant metals and alloys.**

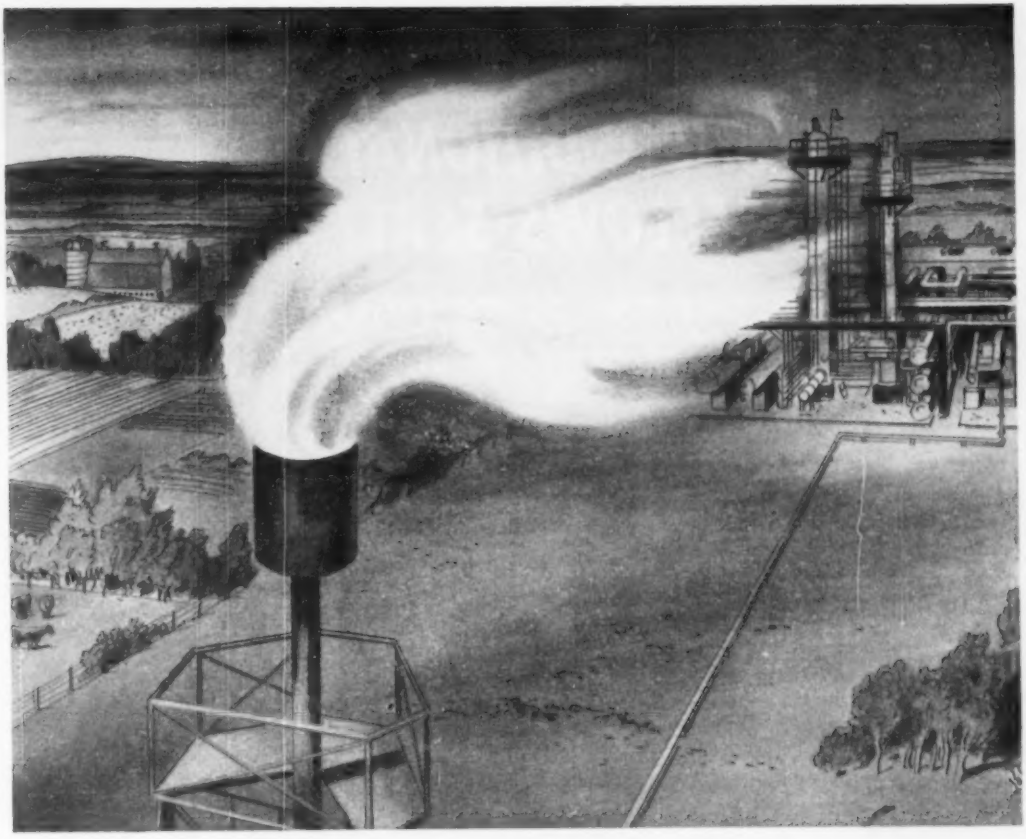
Ask your nearest Distributor—or write direct

The Wm. Powell Co., Cincinnati 22, Ohio

DISTRIBUTORS AND STOCKS IN ALL PRINCIPAL CITIES

Fig. 1793 — Large 125-pound Iron Body Bronze Mounted Gate Valve. Flanged ends, bolted flanged yoke, outside screw rising stem and tapered solid wedge. Also available in All Iron.

POWELL VALVES



Hell-fire or Brimstone

Flares burning hydrogen sulphide are wasteful and may be a dangerous nuisance. The disposal of hydrogen sulphide no longer is a costly problem . . . *it may be a profitable business.* Hydrogen sulphide now is being converted into valuable elemental sulphur . . ."brimstone". . . by Girdler-built sulphur plants. Investigate the Girdler GIRBOTOL plant for economical recovery of hydrogen sulphide from hydrocarbon mixtures and Girdler's sulphur plants of virtually any capacity . . . complete Girdler engineering and construction service for the entire project. Write today for details.

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DESIGNERS, ENGINEERS AND CONSTRUCTORS

For positive valve sealing

...THE UNCONDITIONAL K & M BELLOWS SEAL!

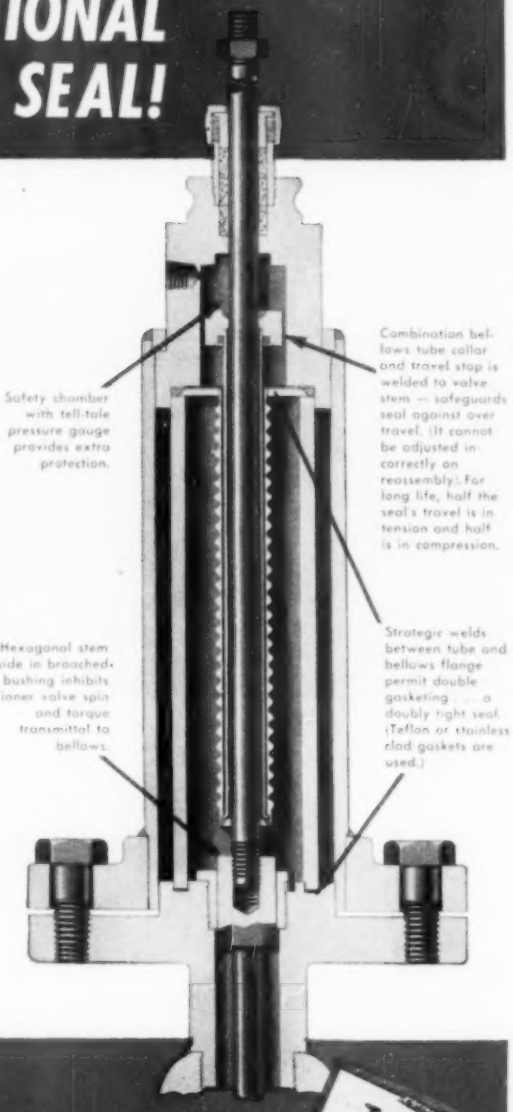
Designed by men who know automatic control valves, the *K & M* Bellows Seal is the ultimate in protection for valuable or toxic process fluids or in vacuum service where air infiltration would be serious.

The seal is engineered to be unconditionally leakproof. Its efficiency is assured by its rugged simplicity . . . by ingenious functional extra safeguards inherent in the unique design of the seal itself.

Study the salient features as indicated on the cutaway view. Note also that the tube collar, the inner tube and the valve stem are positively sealed by welds — not threaded parts. The bellows, too, is sealed permanently at the bottom of the inner tube by a resistance weld; thus pressure is confined to the outside of the bellows where it can be more safely taken . . . furthermore, the bellows cannot buckle.

Here is the absolute seal between valve stem and valve body. Simple. Strong. Sure. Constructed of 3 ply Type 347 or 316 Stainless Steel, for pressures to 500 PSI and temperatures to 600° F. the *K & M* Bellows Seal is available with any *K & M* Diaphragm Motor Valve in sizes from ½ through 3 inches with full travel in each size.

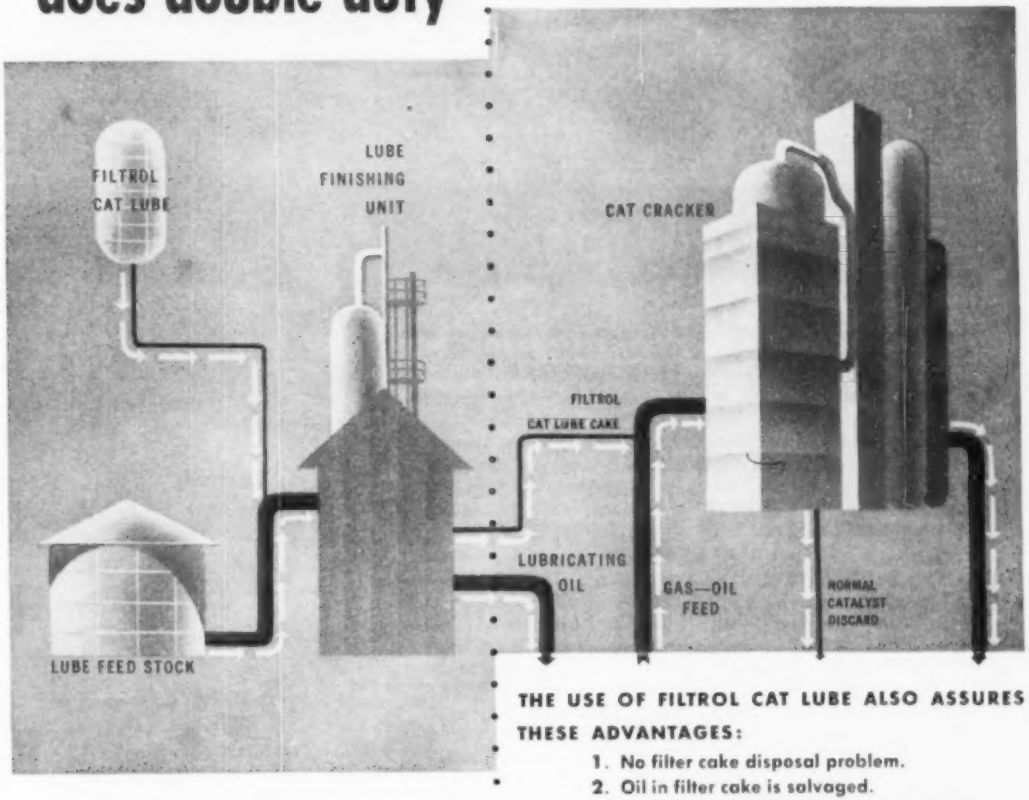
Write for complete details.


Safety chamber with tell-tale pressure gauge provides extra protection.
Combination bellows tube collar and travel stop is welded to valve stem — safeguards seal against over travel. (It cannot be adjusted incorrectly on reassembly). For long life, half the seal's travel is in tension and half is in compression.
Hexagonal stem guide in broached bushing inhibits inner valve spin and torque transmittal to bellows.
Strategic welds between tube and bellows flange permit double gasketing . . . a doubly tight seal. (Teflon or stainless clad gaskets are used.)

KONTROL KIELEY & MUELLER MOTOR

Filtrol* CAT LUBE does double duty

refines lubricating oil and then the spent adsorbent cake serves as a "fluid" cracking catalyst



THE USE OF FILTROL CAT LUBE ALSO ASSURES THESE ADVANTAGES:

1. **No filter cake disposal problem.**
2. **Oil in filter cake is salvaged.**
3. **Provides a constant supply of catalyst at practically no cost.**

An example of the successful use of Filtrol Cat Lube is the highly favorable experience of the Sinclair Refining Company which has been continuously using Filtrol Cat Lube for a year and a half with outstanding results in both lube processing and catalytic cracking.

Sinclair Refining Company was the first of many progressive refiners to take advantage of the economies made possible only through the use of "double duty" Filtrol Cat Lube.

Filtrol

ADSORBENTS • CATALYSTS • DESICCANTS

Write for information

FILTROL CORPORATION

General Offices: 727 W. 7th Street, Los Angeles 17, California
Plants: Vernon, California and Jackson, Mississippi

*T. M. REG. U.S. PAT. OFF.

[*To obtain more data on advertised products see page* 536]

A NEW HIGH!

in Pressure Measurement

80,000 psi

and what it means to you . . .

Whether or not you ever need accurate measurement of pressures in the super-range of 50,000 to 80,000 psi, this new, exclusive helical spring developed by Foxboro illustrates the advance engineering you will get in any Foxboro Pressure Instrument.

Ever since Foxboro introduced the helical pressure element with fixed center of rotation, industry has accepted the accuracy and performance of Foxboro Instruments as standards in the field. These standards may be your answer to immediate pressure problems.

Foxboro has the most complete line of pressure instruments available. You have a choice of rectangular or circular cases . . . spring elements in phosphor bronze, beryllium copper, or Type (316) Stainless Steel. For normal applications, the standard *spiral* and *helical* elements are standards of superior performance . . . rugged, fatigue-free, lastingly accurate. For the difficult, unusual jobs, the new *heavy-duty helical* offers radically new design utilizing the tough, corrosion-resistant properties of Type (316) Stainless Steel . . . particularly adapted to rapidly pulsating service from zero to full pressure . . . responsive and absolutely safe on pressures up to 80,000 psi. Other elements (not illustrated) include: *diaphragm*, 0-1" water to 0-5 psi; *bellows*, 0-5 psi to 0-25 psi; *absolute pressure bellows*, 0-4" mercury to 0-40 psi.

This unequalled range of pressure elements, engineered to the highest standards in instrument design, is your assurance of the best pressure instrument for *any* industrial application. **The Foxboro Company, 246 Neponset Avenue, Foxboro, Mass., U.S.A. Branch offices in principal cities.**

FOXBORO REG. U.S. PAT. OFF. **PRESSURE RECORDERS**

WHAT are the basic principles and essential features of design of a modern Cold Process Water Softener or Clarifier?

WHY is the GRAVER REACTIVATOR superior to other designs of Cold Process units?

HOW does the GRAVER REACTIVATOR operate?

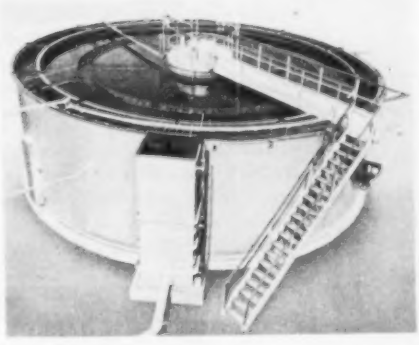
WHEN should the GRAVER REACTIVATOR be used for cold process softening or clarification?

WHERE are GRAVER REACTIVATOR installations in operation and what are the results obtained?

You will find the answers to these questions in a NEW bulletin on the GRAVER REACTIVATOR . . . a high flow rate, upflow solids-contact design of water softener and clarifier.

If your water supply is hard or contains silt, clay, color, organic impurities or other suspended solids, you will find this bulletin informative and helpful. Copies will be sent to plant executives and engineers who write on their Company letterhead.

GW-424



GRAVER

GRAVER WATER CONDITIONING CO.

Dept. 106, 216 West 14th Street, New York 11, New York, U.S.A.

A DIVISION OF GRAVER TANK & MFG. CO. INC. EAST CHICAGO, IND.

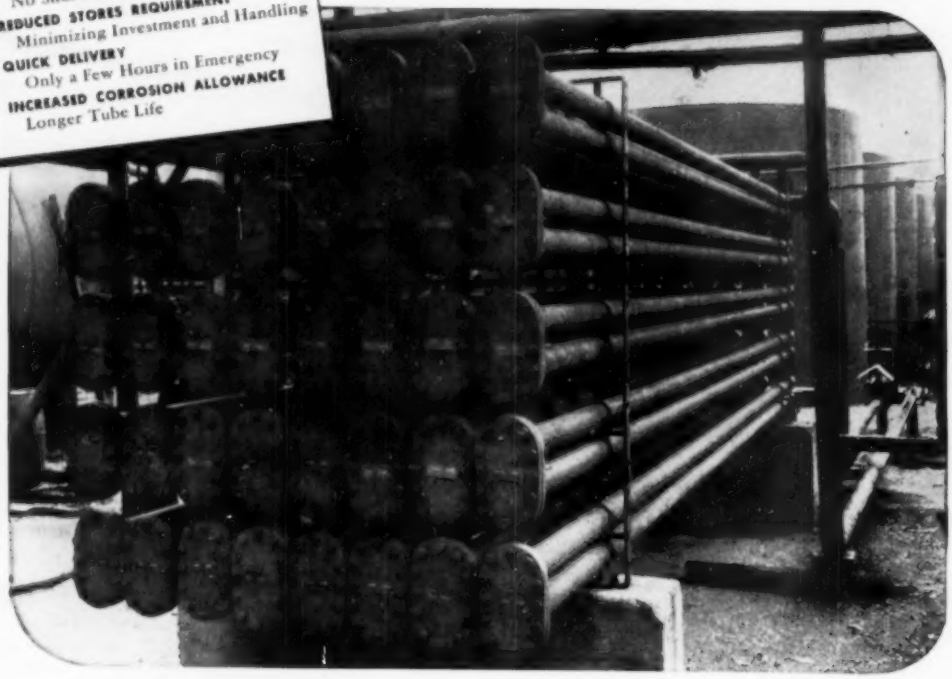
[To obtain more data on advertised products see page 236]

BROWN FINTUBE'S *advantages*

EXTREME FLEXIBILITY
Easily Adapted to Changes in Duty
NO OBSOLESCENCE
Avoiding Waste and Expense
FLANGED HEAD END ASSEMBLY
Eliminating Ground Joint Seals
EASY MAINTENANCE
Using Only Common Tools
CONTINUOUS OPERATION
No Shut-Downs For Cleaning
REDUCED STORES REQUIREMENT
Minimizing Investment and Handling
QUICK DELIVERY
Only a Few Hours in Emergency
INCREASED CORROSION ALLOWANCE
Longer Tube Life

no obsolescence

Brown Fintube Sectional Construction Avoids Needless Waste and Expense



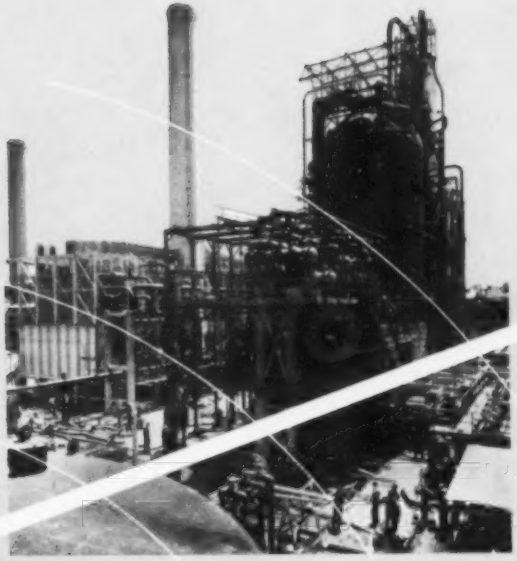
● Brown's interchangeability of parts, exacting design and precision manufacture has "licked" obsolescence.

The sections can be used in one exchanger after another — on different duties — on different products. A bank can even be broken up and the sections shipped to two or more plants, miles apart, assembled and reused. Sections not in use serve as "stores" for other sections on stream. They are *never obsoleted* by changes in duty or plant re-arrangements. You can use, and reuse them, until they are completely worn out.

For the utmost in *efficiency* and *economy*, install Brown's proven, welded fintube heat exchangers throughout your plant. Estimates and quotations furnished promptly. *Write for Bulletin No. 481.*

THE BROWN FINTUBE CO.
ELYRIA, OHIO

SECTIONAL
HAIRPIN
HEAT EXCHANGERS



The Refiner

Foster Wheeler

construction

fabrication

engineering

design

dual control

active liaison between the Refiner and Foster Wheeler in the office, shop and field; . . .

complete agreement on every detail in the design, engineering, fabrication and construction sequence; . . .

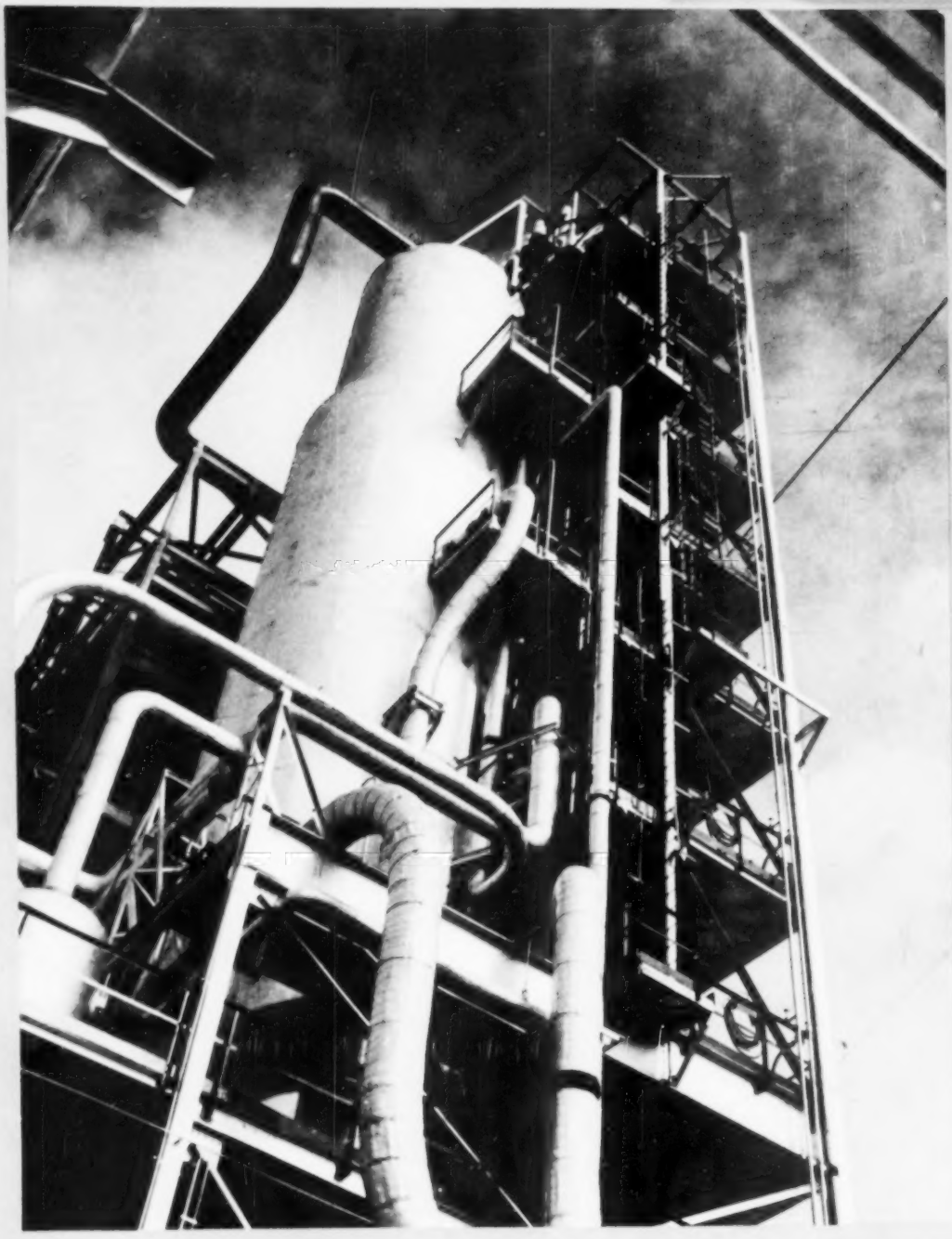
a combined experience that can straighten out unscheduled situations . . .

These are the essential components which provide an accurate and overall dual control which saves time, saves money, and creates another satisfied Foster Wheeler customer.

FOSTER WHEELER CORPORATION

165 BROADWAY, NEW YORK 6, NEW YORK

the complete engineering and construction service anywhere in the world



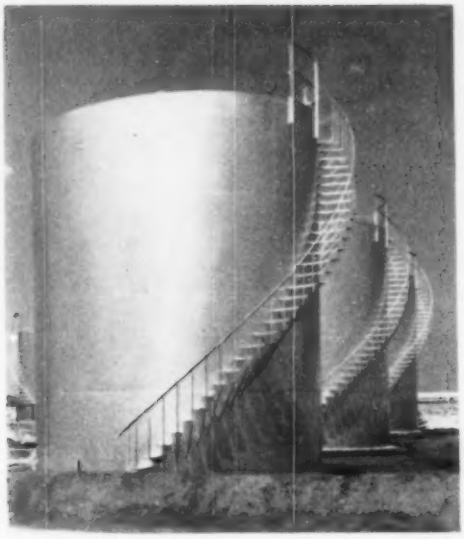
63,000 bbls/day

A top-of-column view of the 63,000 bbl/day Crude Distillation Unit engineered and constructed by Foster Wheeler for the Creole Petroleum Corporation at Amway Bay, Venezuela.

FOSTER WHEELER CORPORATION

165 BROADWAY, NEW YORK 6, NEW YORK

Different tanks solve *different* storage problems



Above: These tanks store fuel oil, kerosene and absorption oil.

Below: These tanks store butane, propane and gasoline. Both views show part of the product storage area of the Burnell-North Pettus Cycling Plant at Pettus, Texas

...at the new Burnell-North Pettus plant

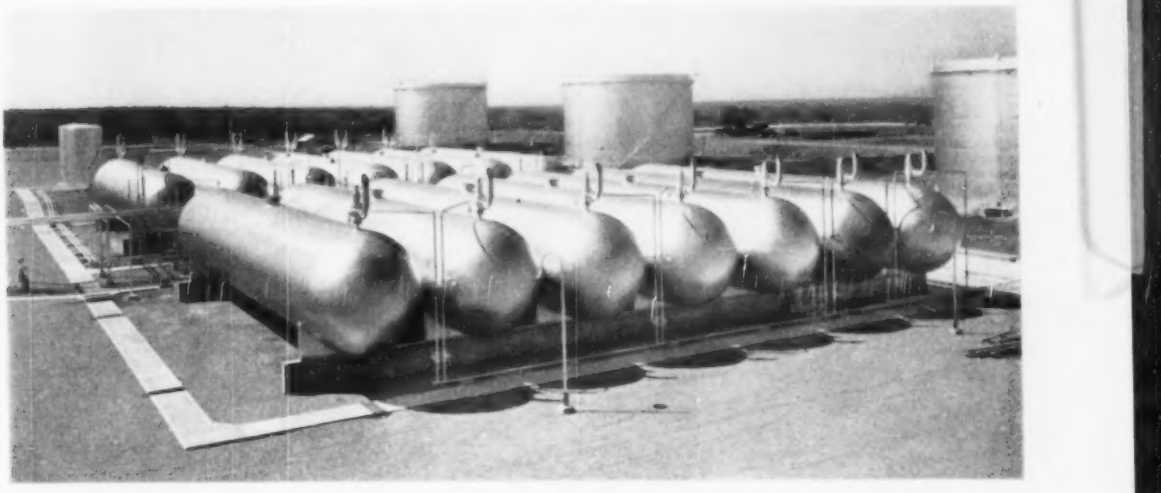
This natural gas cycling plant in Texas is operated by the Stanolind Oil and Gas Company for a group of owners. Products recovered include propane, butane, gasoline, kerosene and fuel oil. Storing such a variety presents problems—problems answered by basing each tank selection on the volatility of the hydrocarbon handled in the tank.

Propane and *butane* would gasify and escape from conventional flat-bottom tanks. But pressure storage prevents excessive losses and reduces the fire hazard. So, for storing the butane and propane, horizontal pressure tanks were specified.

Gasoline is stored in the flat bottom tanks shown below at the right. There are four of these 20,000-bbl. tanks and each is equipped with a Horton Double-Deck Floating Roof. This roof is recommended for flat-bottom tanks storing gasoline because it prevents filling evaporation losses and reduces losses caused by breathing or boiling.

Liquids of low volatility—*kerosene* and *fuel oil*—are stored in the Horton fixed roof tanks shown in the view at the left. Horton welded steel fixed-roof tanks are widely used for storing non-volatile liquids because they do not leak, are easy to maintain and economical to construct.

This example shows why different types of storage tanks are used for different hydrocarbons. Write our nearest office for assistance in picking the right tanks for your products.



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Plants in BIRMINGHAM, CHICAGO, SALT LAKE CITY and GREENVILLE, PENNSYLVANIA

Atlanta 3	2103 Healey Building	Detroit 26	1532 Lafayette Building	Philadelphia 3	1630–1700 Walnut St. Building
Birmingham 1	1527 North Fiftieth Street	Houston 2	2130 National Standard Building	Salt Lake City 4	530 West 17th South Street
Boston 10	1029–201 Devonshire Street	Havana	402 Abreu Building	San Francisco 11	1299–22 Battery St. Building
Chicago 4	2114 McCormick Building	Los Angeles 17	1526 General Petroleum Building	Seattle 1	1330 Henry Building
Cleveland 15	2215 Guildhall Building	New York 6	3310-165 Broadway Building	Tulsa 3	1620 Hunt Building

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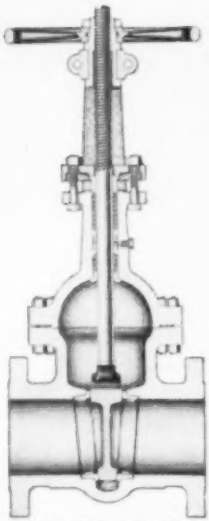
Why shop around for piping materials?

CRANE has everything you need



300-Pound Steel Gate Valve furnished trimmed for oil and oil vapor up to 1100° F.; or steam or water up to 1000° F. Sizes 1½ to 24-inch.

FOR DEPENDABLE SERVICE . . . EASY OPERATION

You can always rely on sturdy Crane Cast Steel Gate Valves. Tight closure is assured by long, close fitting guides that seat the solid wedge disc accurately against screwed-in body seat rings. This guiding action minimizes disc drag, reduces wear on seating surfaces. Minimum resistance to flow is assured by straight-through ports.

Crane design eliminates the possibility of stem binding . . . lengthens service life of packing. Two-piece ball-type gland equalizes pressure on packing even if gland flange is pulled up unevenly. Side strain on stem is eliminated with famous Crane flexible T-head disc-stem connection. Crane steel valves are in pressure classes from 150 to 2500 pounds, with flanged, screwed, or welding ends. See your No. 49 Crane Catalog, p. 226-32.

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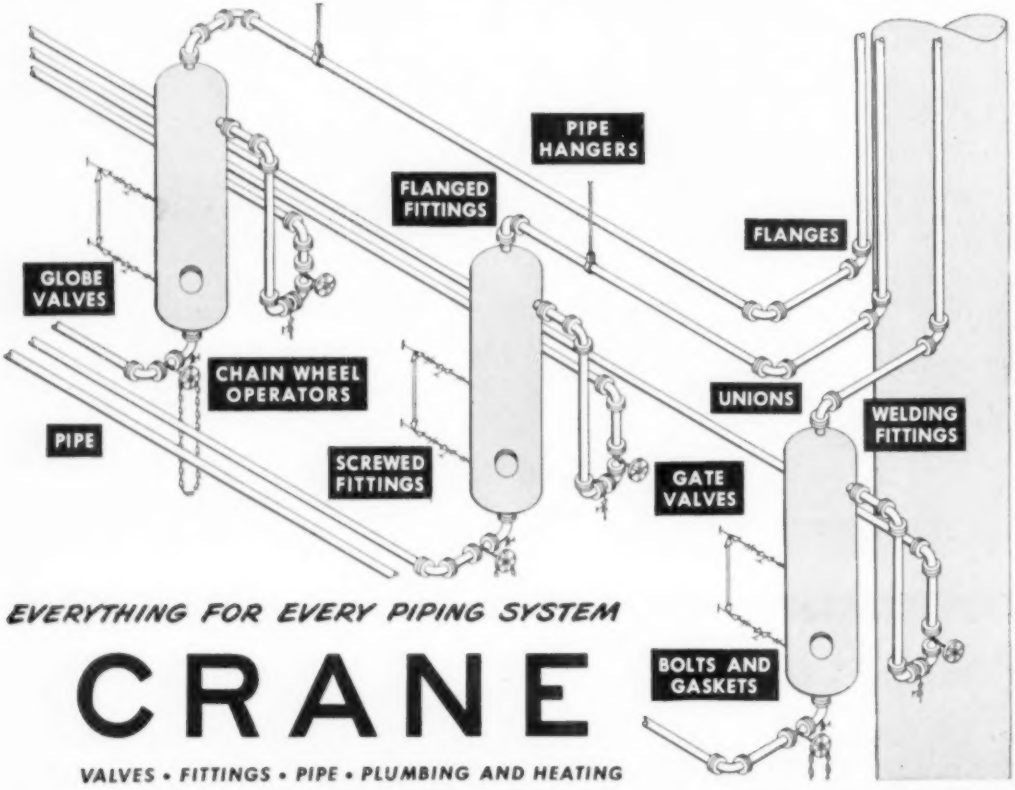

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PETROLEUM PROCESSING
MAY, 1950

Military Raises Standards For Heavy-Duty Motor Oils

OFFICIAL announcement that the Armed Services specifications for heavy-duty engine oils will be changed to include more severe qualification test requirements was made at the Lubricating Oil Discussion Panel, April 14, during the Mid-Year meeting in Cleveland of the National Petroleum Assn. The chief purpose of the change is to insure that approved oils will function satisfactorily with the higher sulfur content fuels in use today in some sections, and anticipated to be in greater use in the future.

R. E. Streets, of the Army Ordnance Research and Development Division, told the meeting that by not later than June, 1951, present Army Specification 2-104B will be superseded by Military Specification 2104. The new standard, MIL 2104, is being designed to cover the heavy duty-engine requirements of Army ground vehicles and also the Diesel engine requirements of the Navy. It will also replace Supplemental Lists 1 and 2 to "Spec" 2-104B, which have been issued within the year to include the high-additive type oils which many oil companies have developed since the war to meet requirements too severe for 2-104B oils.*

The principal difference between the old and new proposed requirements lies in the fuel used in the AXS-1551 test procedure in 2-104B specifications (CRC Designation L-1). The new test fuel is to be a conventionally refined commercial fuel with a minimum natural sulfur content of 0.35%. The present test fuel prescribes only a 0.4% maximum sulfur content. Table 1 shows the characteristics of the 2-104B and the new proposed MIL 2104 test fuels.

"During the war, the 2-104B oils performed satisfactorily in general," stated Mr. Streets. "However, fuels used during that period were predominantly straight-run products of low sulfur content. Thus it must be noted that in the event of another emergency the fuels available for use in Army ground equipment will be composed predominantly of cracked stocks, having a wider distillation range and higher sulfur content. Based on advice obtained from the petroleum industry, the following specifications are representative of the fuels the Army must use in a future emergency (See Table 2).

"The trend in military engine design, both gasoline and Diesel, is toward light-weight, high-output engines of small over-all dimensions. This same trend is in evidence in commercial truck engines which are being used by the military to replace equipment used in the last war.

"The combined changes in both fuels and engines in the direction of increased severity have put a heavy demand on the lubricating oil. Commercially, Supplement 1 and Supplement 2 oils are coming into wider use to combat such conditions as excessive sludge, varnish, oil ring and ring groove plugging, and high wear. Although they were developed initially for use in Diesel engines, these oils have given outstanding performance in gasoline engines operating under severe conditions.

"The military fleet is a mixed one in which the number of gasoline engines by far exceeds the number of Diesel engines. Logistically, it is mandatory that a single type oil be supplied. Therefore a compromise must be reached which will satisfy the requirements of both types of engines and at the same time assure wartime availability of the products specified."

It is considered, according to Mr. Streets, that MIL 2104 represents a reasonable compromise between gasoline and Diesel engine requirements and wartime availability, rather than the best answer to any single requirement. For these reasons, it is felt that the new specification will remain substantially un-

*"New Type Heavy-Duty Motor Oils Carry Up to 20% Additive," by V. B. Guthrie. PETROLEUM PROCESSING, 4, No. 9, 981 (Sept. 1949).

TABLE 1—Characteristics of Proposed New Fuel For Heavy-Duty Engine Oil Test Procedure

ASTM Distillation	MIL 2104	2-104B
50% Evap., Temp., °F.	500 min.	
90% Evap., Temp., °F.	600-640	550-575
End Point, Temp., °F.	650-690	625 max.
Sulfur, wt. %	0.35 min. natural	0.4% max.
Cetane No.	40-45	43-53

TABLE 2—Specifications Representative of Fuels Available to Army in Future Emergency

Motor Fuel—MIL-G-3056	
ASTM Distillation	Type A
10% Evap., °F.	140-158
50% Evap., °F.	190-221
90% Evap., °F.	270-329
RVP, lbs., max.	8
Octane No., F-2	80
Gum, mg./100ml., max.	4
Sulfur, Wt.%, max.	0.25
TEL, ml./gal., max.	3
Diesel Fuel—USA Spec. 2-102C	
Distillation	Grade A
90% Evap., °F., max.	675
End Point, °F., max.	725
Cetane No., min.	40
Sulfur, Wt.%, max.	1.25

changed for at least the next 5 years.

In discussing the proposed fuel for the new test procedure for heavy-duty engine oils, Mr. Streets said that the use of additives of any kind in order to produce a clean fuel or solvent treating of the fuel is not permitted. Additives to increase the sulfur content above the 0.35% minimum natural sulfur specified will be permitted after approval of the additive sulfur compound by the Ordnance Department.

Because of the lack of reproducibility of the bomb method for determining sulfur content, it is required that Armour Research Foundation check the sulfur content of all AXS-1551 test fuels reported at 0.40% sulfur or below. In discussing the need for improved oils for Army ground vehicles in heavy-duty service, Mr. Streets said:

"A very serious problem was encountered early in 1945 when engine sludging of transport vehicles became widespread in certain areas of the Zone of Interior. Clogging of oil control rings and oil pump screens occurred in less than 20,000 miles. The source of supply of fuel varied but all vehicles were using the same 2-104B oil. This fuel was procured under U. S. Army Specification 2-114B and until this time consisted largely of straight-run stock.

"However, as the production of aviation gasoline tapered off, a high percentage of these cracked stocks was blended with the motor fuel and, as a result, a great increase in engine dirtiness resulted in certain areas and with certain oils. At the same time, no trouble was encountered in theatres of operation where 2-103C gasoline and 2-104B engine oil were used."

The composition of future military gasoline for ground use is dictated by other requirements, said Mr. Streets, and will certainly not improve. "Furthermore, engine design and operating conditions would appear to be such that any changes will be in the direction of increased severity rather than a decrease. Hence, the only basic factor that can readily be improved is the lubricant."

Questions Need for Change

C. O. Tongberg, Standard Oil Development Co., presented a prepared statement on the subject of the proposed new specifications at the NPA Lubricating Oil Discussion Panel. "Our organization feels," he stated, "that before a well-established military specification is changed, there should be no question regarding the need for the change in the specification requirements, and no question of the adequacy of the new specification." With regard to the proposed MIL 2104 he said there is considerable question regarding the technical justification for its adoption.

Among the points at issue, Mr. Tongberg said are: What is the basis on which 2-104B oils are now considered unsatisfactory? Where are the data? In what respect is improvement in performance needed? To what degree has it been established that indicated malperformance of equipment is due to oil quality and not to poor mechanical design features?

"It appears that MIL 2104 was proposed as a compromise between what the Military needs, and what commercial operators of automotive equipment would be willing to accept," he continued. "Although this may not have been the case, we feel very strongly that there should be a separation between the requirements of the Military and the requirements of civilian automotive equipment. Military and civilian requirements are significantly different.

"The use of a common specification will, therefore, either give the Military a product which will not meet their requirements, or force the commercial operator to use a higher priced product in place of one which is already giving him satisfactory performance.

"Since the Military and civilian requirements differ, oil companies should market lubricants most suitable from a performance and cost standpoint for the particular type of service involved.

Sees Possible Cost Increase

J. M. Miller, Automotive Division, Standard Oil Co. (Ind.), raised the question as to whether engine builders would continue to demand Supplement 1 and 2 oils in addition to the proposed MIL 2104. If so, he said, the result would be to raise the cost floor of heavy-duty motor oils without meeting the desires of users and engine builders confronted with the two-way problem of "fuel" and "service." Three types of heavy-duty oils would continue to be required, with the accompanying disability to the oil company of limited distribution and costly inventory.

"Gasoline engines are not troubled by sulfur in fuels to the same extent as Diesel engines," said Mr. Miller. "While recognizing that there are other factors besides sulfur to consider in evaluating Diesel fuel effects on engine operation, the effect of sulfur cannot be overlooked. Surveys, both private and public, show that large volumes of diesel fuels containing 0.75% to 1.0% of sulfur are being sold for high speed Diesels in stationary and highway service. It is unlikely that such fuels will disappear from the market, an inescapable fact in considering the fuel/lubricating oil problem in Diesel engines.

"Fortunately, it appears that, if an L-1 diesel test fuel with a distillation range similar to the proposed test fuel but containing at least 0.5% sulfur is required, the extreme demands of Diesel and of gasoline burning engines in both 'lugging' and cold operation might well be satisfied. Thus, improved lubrication of all engine types, irrespective of service or fuel quality, will be insured with only two heavy-duty oils in place of the present three."

Necessity for Complete Data

With the introduction of the new MIL 2104 oil, which is intermediate in both price and quality between the present 2-104B and the Supplemental List 1 oil, there are now six classes of price and quality for lubricating oils, H. C. Mougey, Technical Director, Research Laboratories Division, General Motors Corp., told the Lubricating Oil Panel. These oils Mr. Mougey listed as:

Name of Oil	Type of Oil
Regular	Straight Mineral
Premium	Filling Station Oil
Heavy-Duty	2-104B
Heavy-Duty	Military 2104
Super Duty	Supplemental List 1
Super Duty	Supplemental List 2

"The men in the oil and automotive industries who are concerned with the lubrication of gasoline and Diesel engines under the different operating conditions all want to know which of these oils should be marketed, and under what operating conditions these different oils will be of most value to the engine operator.

"A large number of oil companies now have Supplemental List 1 oils and experience in actual service has shown these oils may be very satisfactory under some operating conditions, such as in bread-wagons, taxicabs, or in high speed trucking where at least some of the Premium and 2-104B oils may not be able to prevent the accumulation of excessive amounts of sludge and varnish.

"On the other hand, although 2-104B oils may not be able to prevent the accumulation of sludge and varnish under certain conditions, they have given a wonderful account of themselves during the 10 years since they were developed, and their war record is one of which we are all very proud. Also, they are lower in cost than some of the oils containing larger amounts of addition agents.

"We should not give up satisfactory oils which we now have, in the hope that some new oil will make the present oils unnecessary, until and unless we have determined that we can make this change with safety. In the meantime, it appears that the men who are interested in lubrication in both the oil and automotive industries should do everything they can to obtain service records with these oils of different classifications so that they will be able to make the necessary decisions with their actions based on reliable records covering performance in service under the different operating conditions."

New Burnell-N. Pettus Cycling Plant Recovers 330,000 Gal./Day of Liquids

By D. P. THORNTON, Jr.
Southwestern Editor

Latest example of a growing trend in the natural gasoline industry of the Southwest is the large and highly-flexible Burnell-N Pettus Cycling Plant, described here. It handles 194,000 Mcf. of gas condensate and casinghead gas daily, and recovers 330,000 gal. of products.

Among its other unusual features are two separate systems handling casinghead and gas condensate, while distillate is processed separately from rich oil.

Another innovation features a mid-section pumparound circuit through a fired heater to provide process heat to the primary still, which stabilizes heater duty while reducing pressure vessel requirements. A "propanizing" absorber on the recycling gas stream recovers C_3+ components from recycle gas with rich oil partially stripping the latter of methane and ethane to minimize oil circulation.

High pressure steam is used for power generation and principal mechanical drives throughout the plant, with exhaust steam used for process heat and stripping. Compressors totaling 9200 h.p. are installed to handle casinghead gas, recycle gas and 3200 psi. reinjection gas.

ONE of the largest gas cycling plants in the Southwest has recently been completed near Pettus, Texas. It features a design throughput capacity of 194,000 Mcfd. of gas condensate and casinghead gas combined, with liquid hydrocarbon recovery in excess of 330,000 gal. daily.

Its products run the range from propane and butane through finished motor fuel, kerosine and No. 2 fuel oil. The plant was designed and built by Jones & Laughlin Supply Co., in cooperation with Stanolind Oil & Gas Co. engineers and a Joint Owners' engineering committee.

Operated by Stanolind for its own account and that of 20-odd other owners, the plant processes gas from the Burnell and North Pettus condensate fields of Bee, Karnes and Goliad counties and a ring of crude oil wells surrounding these two principal fields. Most of the residue gas above plant and field fuel needs is returned to the producing reservoirs at 3200 psig., while about 30,000 Mcfd. is sold to United Gas Pipe Line Co. at 800 psig.

There are two distinct gas processing systems; one handles casinghead, and the other gas condensate. In addition, distillate separated from incoming condensate gas is processed separately from the main rich oil stream.

Production from the 31 condensate gas wells to which the plant is presently connected is controlled by chokes located within the plant, and a single test separator serves all these wells. The individual wells are completely equipped, also, to protect the wells and provide control in event of a gathering line failure. Residue gas is returned to seven injection wells, three in the Burnell and four in the North Pettus fields.

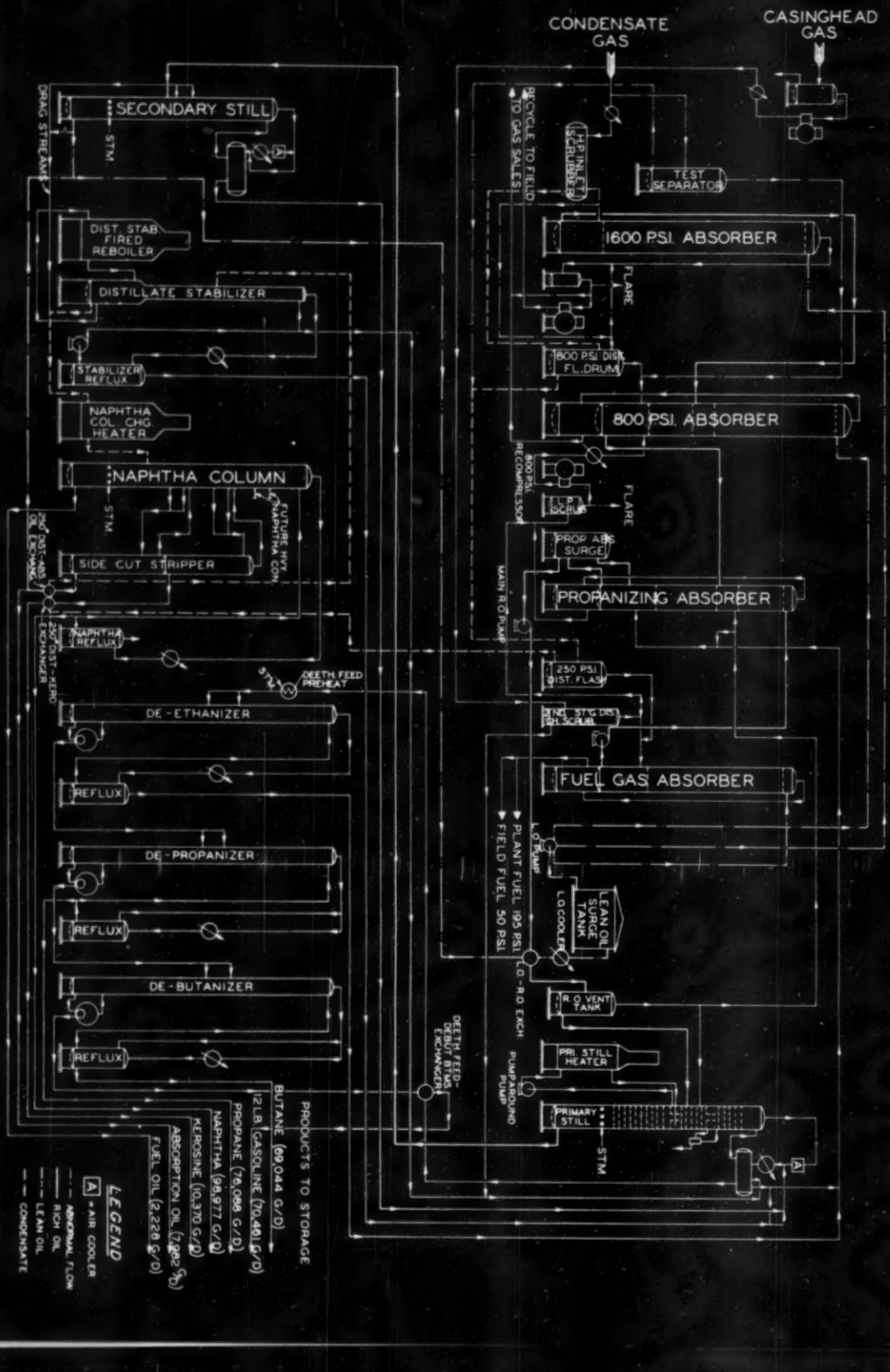
An unusual feature is found in the primary still, which uses a mid-section pumparound circuit through a fired heater for process heat instead of the more conventional practice of heating total still feed. This permits high operating flexibility, provides an all liquid charge to the heater at optimum, stable operating conditions regardless of minor fluctuations in plant load, and reduces pressure vessel requirements.

There are two features in the plant utilities, somewhat unusual for cycling or natural gasoline plant construction although common enough in other industrial installations—use of turbogenerators for electric power, and deaerators and evaporators to provide distilled water makeup to boiler feedwater and engine jacket water circuits. The plant also is equipped with a complete lead blending plant, permitting it to produce a motor gasoline in the premium octane bracket.

Another interesting aspect of the design is the "propanizing" absorber. Rich oil from the 800 psi. (sales gas) absorber flows over the trays in the lower section, absorbing propane and heavier components from the relatively rich recycle gas, and at the same time being partially stripped of its methane and ethane content. Using fat oil (relatively lean) from the casinghead gas (fuel gas) absorber as the absorption medium in the upper portion of the propanizing absorber, the quantity

Plant Owners

Anderson-Prichard Oil Corp.
Atlantic Refining Co.
Bauchman, Lelia A.
Bauchman, James B.
Bauchman, John Allen
Blumberg, Jane and Roland K.
Bradley, E. G.
Brown, George R.
Brown, Herman
Continental Oil Co.
Eaton, Marquis, (Trustee for Lelia A. Bauchman, James B. Bauchman, John Allen Bauchman, E. G. Bradley, H. N. Mallon, J. B. O'Connor, Rock Hill Oil Co., E. A. Tapp, and H. H. Weinert)
Gas Properties, Inc.
Highland Oil Co.
Luling Oil and Gas Co.
Magnolia Petroleum Co.
Mallon, H. N.
Maracaibo Oil Exploration Corp.
O'Connor, J. B.
Phillips Petroleum Co.
Rock Hill Oil Co.
Russ Oil Corp.
Slick-Moorman Oil Co.
Stanolind Oil and Gas Co.
Stewart Petroleum Co.
Sun Oil Co.
Weinert, H. H.


CONDENSATE GAS
CASINGHEAD GAS
SECONDARY STILL
STM.
DRAG STREAM
DIST STAB FIRED REBOILER
DISTILLATE STABILIZER
STABILIZER REFLUX
NAPHTHA COL. CHG. HEATER
NAPHTHA COLUMN
STM.
FUTURE HYV NAPHTHA CON
SIDE CUT STRIPPER
250° DIST-ABS OIL EXCHANGE
250° DIST-KERO EXCHANGER
NAPHTHA REFLUX
DEETH FEED PREHEAT
DE-ETHANIZER
REFLUX
DE-PROPANIZER
REFLUX
DE-BUTANIZER
REFLUX
DEETH FEED-DEBUT BTMS EXCHANGER
PRODUCTS TO STORAGE
BUTANE (69,044 G/D)
12 LB. GASOLINE (70,481 G/D)
PROPANE (76,088 G/D)
NAPHTHA (98,977 G/D)
KEROSINE (103,70 G/D)
ABSORPTION OIL (7882 %)
FUEL OIL (2,228 G/D)
LEGEND
A - AIR COOLER
ABNORMAL FLOW
RICH OIL
LEAN OIL
CONDENSATE
RECYCLE TO FIELD TO GAS SALES
H.P. INLET SCRUBBER
TEST SEPARATOR
1600 PSI. ABSORBER
FLARE
1600 PSI. DISC. FL. DRUM
800 PSI. ABSORBER
800 PSI. RECOMPRESSOR
L.P. SCRUB
FLARE
PROP. ABS. SURGE
MAIN R.O. PUMP
PROPANIZING ABSORBER
250 PSI. DIST. FLASH
2ND. STG. DIS. FL. SCRUB
FUEL GAS ABSORBER
PLANT FUEL 195 PSI
FIELD FUEL 50 PSI
L.O. PUMP
L.O. COOLER
LEAN OIL SURGE TANK
L.O.-R.O. EXCH.
R.O. VENT TANK
PRI. STILL HEATER
PUMPAROUND PUMP
PRIMARY STILL
STM.

of propane and heavier hydrocarbons in the recycle vapors overhead from this absorber is reduced. At the same time the total lean oil requirement of the plant is not increased.

Drag streams from the secondary still are utilized to remove light ends from the absorption oil and also to continually remove undesirable heavy impurities. These are charged to the naphtha column, which recovers the light ends and also drops the heavy ends into the residue sold as fuel oil.

It will be recognized that much of the processing is conventional. It is not possible in the allotted space to present a highly detailed flowsheet, hence the schematic diagram of Fig. 1 has been included to show the general scheme, although much of the control instrumentation and non-essential auxiliary vessels have been eliminated in the interests of simplification.

Gas Inlet System

High pressure condensate gas is brought to the plant site under full well-head pressure through 19 separate gathering lines which converge on a metering station. The station is shown in Figs. 2 and 3. After metering, the flow is controlled through adjustable well-head type chokes which reduce the pressure to approximately 1630 psi. The gas then enters one of two headers, one connected to the plant test separator which can operate up to 920 psi., and the second, or normal flow, to the plant intake scrubbers via a pressure reducing valve lowering the pressure to 1610 psig., and a field gas cooler (estimated inlet temperature 130° F.).

Scrubber effluent gas is split equally between the three 1600 psi. high pressure absorbers, but up to 15,000 Mcfd. of gas may be further reduced in pressure, bypassed around the high pressure absorbers to the 800 psi. distillate flash drum, thence to the 800 psi. absorber and ultimately to sales gas. The entire condensate gas inlet may be diverted to sales if absorbers are out of service. A by-pass heater has been provided to warm the wet gas to about 115° F. before reduction to 800 psi. to prevent hydrate formation at and downstream of the pressure reduction valve. Scrubber liquid—condensate—passes to the 800 psi. flash drum.

When a well is connected to the test separator, the metered separator overhead gas is charged to the 800 psi. absorber. The liquid, likewise measured for test purposes, is charged to the 250 psi. flash drum, vapors from which go to the fuel gas absorber. The liquid from this flash is charged to the distillate stabilizer.

Casinghead gas comes to the plant through three lines conventionally equipped with drip tanks, meters and scrubbers. It is compressed to 200 psig. as feed to the "fuel gas" or low pressure absorber. Pressure is maintained at or below 2 psig. at the plant suction to avoid excessive back pressure on well separators. Volume is currently 7000 Mcfd., but equipment is sized to handle twice that much with the installation of additional compressors and after-coolers.

Condensate Gas Processing System

Each of the high pressure absorbers is a 5 ft. x 53 ft.-9 in. vessel having 20 trays on 27 in. spacing and a mist extractor. Design lean oil circulation is 388 gpm. to each. In normal operation absorber residue gas is taken to the 1600 psi. injection gas compressors, but absorber residue gas may be diverted to main-

Fig. 1—Schematic flow diagram of the processing arrangements at the new Burnell-N. Pettus cycling plant, one of the largest in the Southwest. Note that gas condensate is processed separately from light hydrocarbons absorbed from incoming "wet" gas, and also the processing flexibility which is available

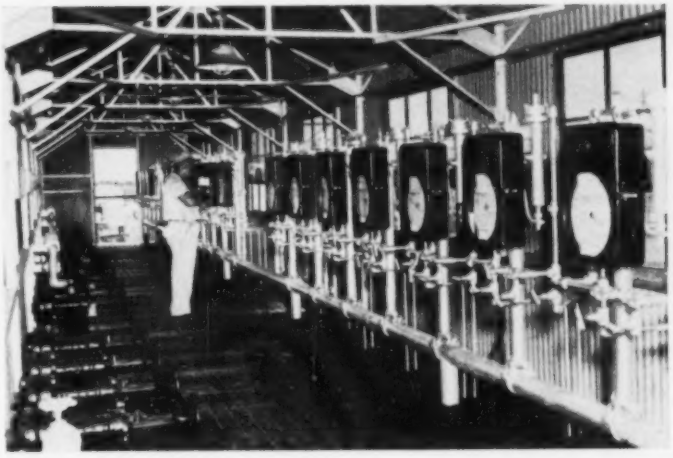
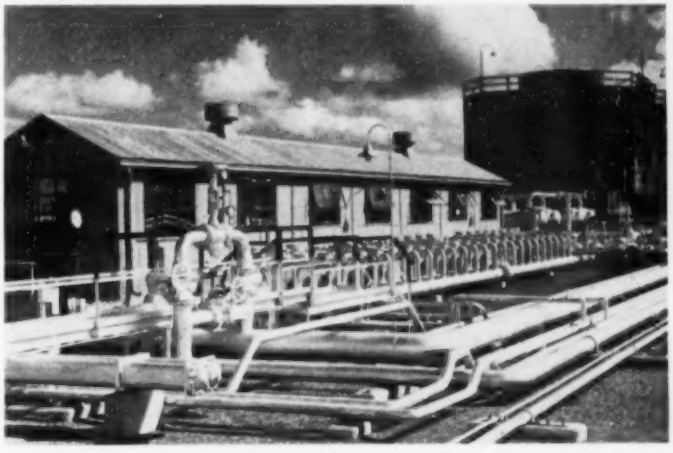


Fig. 2 (above) and Fig. 3 (below)—Interior and exterior of the inlet meter house, showing metering equipment and manifolding. Thirty-one condensate wells are hooked to the 19 gathering lines shown in this picture, while three more bring in casinghead gas



tain sales gas line pressure. The compressors discharge at 3200 psig. to the field distribution line.

Liquid from the condensate gas inlet scrubber is charged to the 800 psig. distillate flash drum, vapors from which constitute one of the three normal sources of feed for the 800 psig. absorber. The others are gas bypassed around the high pressure absorbers and 800 psig. recompressor gas. Intermittently, gas from the test separator is the fourth feed source of this absorber.

The single 800 psi. absorber is 5 ft. by 74 ft.-1 in., with 20 trays and a mist extractor in the absorption section and six side-to-side trays on 20 in. spacing in the propanizing section. Rich oil from the bottom of the high pressure absorbers enters just above the propanizing section, while vapors from the 800 psig. flash drum may enter either with the 1600-lb. rich oil or below the propanizing section. Recompressed vapors enter below the propanizing section.

The 800 psi. residue gas scrubber is built into the base of the absorber, the advantage being the saving of one head for the vessel and utilizing the same foundation. A similar construction is used in the propanizing and fuel gas absorbers. The scrubbed gas is reduced to sales gas line pressure and any excess is utilized for plant and lease fuel.

The propanizing absorber is 6 ft. by 58 ft.-4 in., contains 12 sieve and 6 bubble trays. Fat oil from the 800 psi. absorber feeds into the propanizing absorber, entering above the sieve trays, and absorbs part of the propane and heavier content of the relatively rich recycle vapors from the primary still reflux tank. At the same the 800 psi. rich oil is partially stripped of its methane and ethane content. The bubble trays in the top section similarly treat fat oil from the low pressure absorber.

Casinghead gas processing is much simpler. Here the scrubbed gas enters a conventional 4 ft. by 57 ft. 20-tray absorber operating at 195 psig. Residue gas is scrubbed in the base of the tower for the same reason as previously stated for the 800 psi. and propanizing absorbers, passing directly to plant and lease fuel. The rich oil, as indicated earlier, enters the top of the propanizing absorber for partial de-ethanization and, mixed with rich oil from condensate gas absorption, passes to the rich oil vent tank, exchanging heat with stripped lean oil en route.

Light Hydrocarbon Processing

Rich oil from the propanizing absorber surge tank is pumped through the rich-to-lean oil exchangers to the rich oil vent tank. Oil from the vent tank enters the still on the 12th tray, and vapor enters above the 14th tray. Normal feed temperature is 370-375° F.

The primary still operates at 225 psig., its function being to strip out enough of the light, absorbed hydrocarbons to allow the secondary still to operate totally condensing. The necessary heat is supplied by a pumparound circuit through the primary still heater. A partitioned center-well collects overflow from tray 11. The pump takes suction on this well and moves up to 1736 gpm. of oil through the primary still heater (Petro-Chem), where temperature is raised to about 500° F., and returns to the outlet side of the still center well. The partition between the hot and cold sides of the center well is lower than the outlet weir to tray 10 so, if still feed is interrupted, the suction side of the center well will fill from the hot side. The amount of pumparound may be controlled as desired.

The quantity of stripping steam admitted below the first tray of the primary still is 8874 lbs./hr. at design conditions. The amount is controlled to permit total condensing operation of the secondary still.

Overhead vapors from the primary still are air-cooled from about 230° F. to 160° F., then aftercooled with water to 95° F. Between the air-cooler and aftercooler, vapor and liquid from the distillate stabilizer reflux tank as well as the secondary still net product liquid and any high vapor pressure propane to be re-run also are introduced into the line ahead of the aftercooler and thence to the primary still reflux tank. This last also serves as feed accumulator for the de-ethanizer. Vapors off this tank return to the propanizing absorber without pressure control, thus the primary still floats on the propanizing absorber.

The level controller in the base of the primary still controls secondary still feed, which enters above tray 16. The secondary still separates lean oil from absorbed hydrocarbons. Fractions lighter than about 350° F. endpoint pass overhead at 240° F. to the air cooled condenser, leaving at about 160° F. partially condensed. The after-cooler totally condenses and cools them to 100° F. Still pressure is controlled by by-passing hot vapors into the still reflux tank.

A fraction, boiling between gasoline and absorption oil, may be withdrawn as a sidestream from either the dehydrating tray downcomer or the downcomer of tray 18, and amounts to approximately 2 gpm. This drawoff line connects with the absorption oil drag stream and pressures into the naphtha heater charge stream. Stripping steam comes from the 90 psig. superheated steam system and may amount to as much as 20,280 lb./hr.

The oil from the base of the secondary still passes through the primary still oil-to-oil exchangers enroute to the lean oil cooler, a drag stream being taken off to the naphtha still, which also serves as an absorption oil reclaimer. Oil enters the lean oil surge tank at 95° F. The lean oil pump (turbine driven multistage Pacific centrifugal with two interstage bleeds, 100% spared) takes suction on this tank to provide oil at three different pressures to the three lean oil services (fuel gas absorber, 235 psig., 208 gpm.; 800 psig. absorber, 865 psig., 330 gpm.; and high pressure absorbers, 1640 psig. and 1164 gpm.).

De-ethanizer feed preheat is obtained by exchange against debutani-

TABLE 1—Fractionator Design Operating Conditions

	De-ethanizer	Depropanizer	Debutanizer*	Distillate Stabilizer	Naphtha***
Pressure, psig.	505	225	90	240	7
Temperature, ° F.					
Top	123	120	140	146	310
Feed inlet	200	...	200	157	485
Reboiler outlet	262	260	270	350**	450††
Reflux					
Temperature, ° F.	95 or lower	100	100	104	95
Reflux to Feed Molal Ratio	0.65	1.29	1.42	0.27	0.46
First reboiler circulation, gal/min.	...	...	...	356	...

* Making 12 lb. RVP natural gasoline.
** Bottom temperature 475° F.
*** Making absorption oil and rerunning 12 gpm of lean oil.
†† Bottom temperature.

TABLE 2—Typical Winter Gasoline Analysis

ASTM Distillation:	Sample Test	Area Specification
IBP	92	95*
10%	121	130*
50%	203	239*
90%	345	375*
End Point	413	437*
Residue, %	0.5	2.0*
Gum, mg. 100 ml.	None	3*
Sulfur, %	0.019	0.2
Corrosion, Cu. Strip	Neg.	Neg.
Oxidation Stability, min.	850	240**
Vapor Pressure, Reid, psig.	11.0	11.0*
Octane Number:		
Research, 3 cc TEL Max.	86.5***	81.0**
ASTM, Clear	67.8	64.0**

* Maximum
** Minimum
*** 84.2 with 2 cc TEL

zer bottoms and, finally, 90 psig. steam, to a controlled inlet temperature of 200° F. on trays 14 or 18. Column conditions are given in Table 1. Uncondensed overhead vapors from the reflux tank are returned to the propanizing absorber.

De-ethanizer bottoms are depropanizer feed, entering on either the 18th or 22nd tray. Depropanizer design operating conditions are given in Table 1. Gross overhead vapors are totally condensed with backpressure control similar to that for the primary still.

The debutanizer, charging depropanizer bottoms, has been designed to make from 12 to 26-lb. RVP natural gasoline off the base, as desired, with 95% purity mixed butanes as the net overhead product. For 12-lb. gasoline the approximate operating conditions are given in Table 1. Typical product test data (motor fuel blend) are given in Table 2. Column back pressure is maintained in the overhead vapor line, bypassing enough vapor to the reflux tank to hold a pressure slightly below tower pressure, in maintaining a constant pressure on condenser and tank. Stablized natural gasoline is withdrawn through the de-ethanizer feed exchanger and through coolers to storage.

Liquid Condensate Processing

Condensate from the 250 psi. distillate flash drum exchanges against naphtha column side draw streams to a preheat of about 157° F. before entering the distillate stabilizer on tray 10. The stabilizer separates all propane and lighter from the distillate. Design operating conditions appear in Table 1. Overhead is partially condensed, vapors from the reflux tank entering the inlet side of the primary still overhead aftercooler. The liquid excess over reflux also enters this condenser.

The bottom product splits, part going to a single coil Petro-Chem heater serving as a direct-fired reboiler, and the balance to another Petro-Chem heater, where, with the absorption oil drag stream and the secondary still side draw drag stream it constitutes naphtha column charge. Column duty is to split the charge into a blending naphtha of 400° F. end point, a kerosine cut, absorption oil and fuel oil bottoms. All fractions heavier than kerosine are withdrawn as fuel oil.

Column overhead is totally condensed. The kerosine sidestream is taken from trays 16 or 18 into the upper section of a side-cut stripper and to storage. Absorption oil is withdrawn from either trays 10 or 12 into the lower stripper section and thence to storage or the lean oil system as required. The tower also is equipped to make a light naphtha cut between the gasoline and kerosine fractions if desired at some future time.

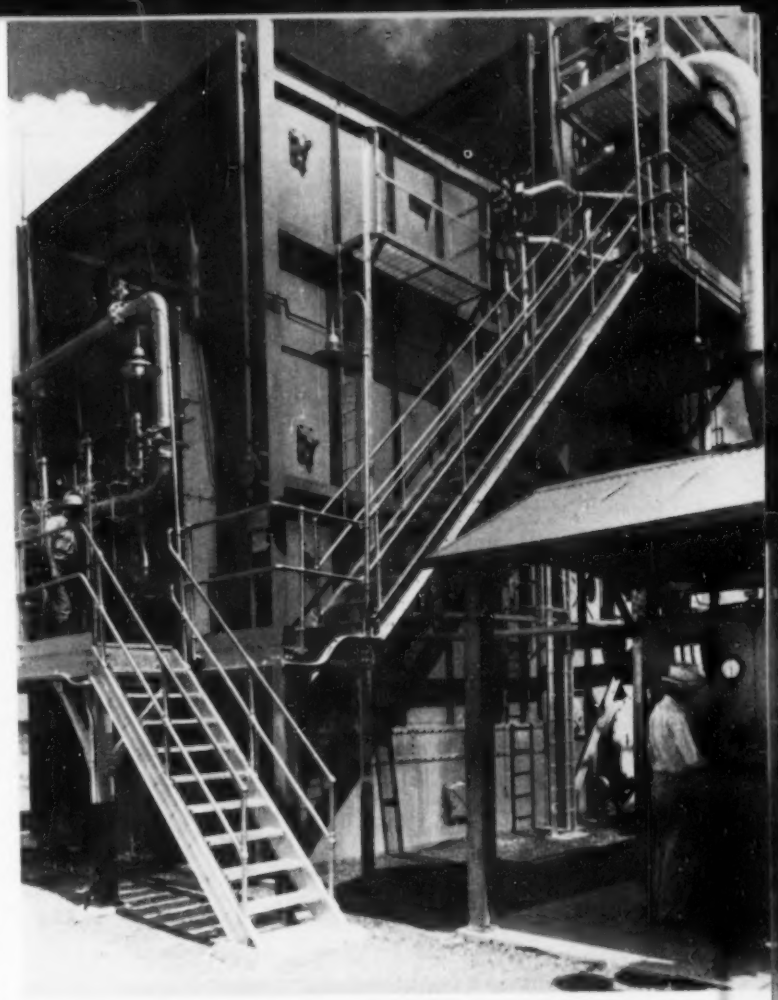


Fig. 4—Closeup view of one of the two 90,000 lbs./hr. Combustion Engineering water tube boilers, which supply all plant steam requirements for electric power, prime movers and processing. Steam is generated at 650 psig., 750° F.

Plant Utilities

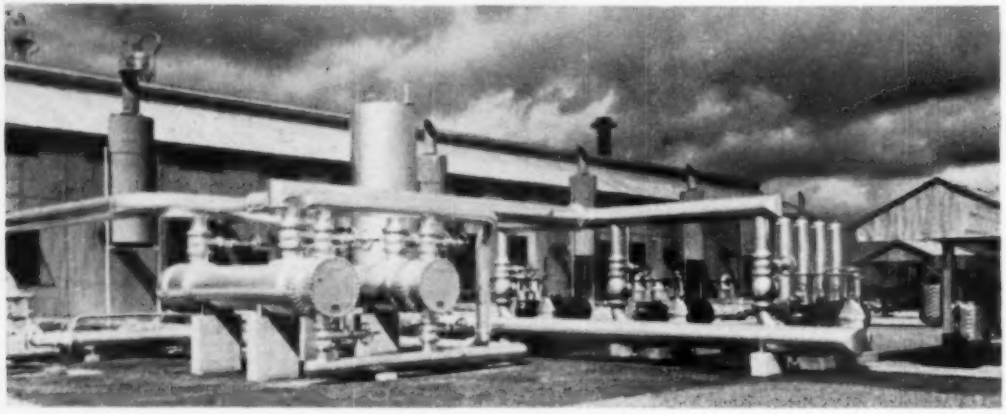
Plant utilities comprise steam and electric power generation and water services. Steam is generated at 600 psig., 750° F. in two 90,000 lb./hr. Combustion Engineering Co. water tube boilers, Fig. 4. There are four steam pressure levels in the plant; 600 psig., serving the turbogenerators, main lean oil pumps, and principal mechanical drive turbines; 250 psig. exhaust steam from the primary still pump around pumps, used as stripping steam in the primary still; 90 psig. exhaust from lean oil and process area turbines, used for process heating; and 50 psig. exhaust from the boiler area pumps, used for deaerator and evaporator steam heating. Turbogenerators are fully condensing.

Boiler feedwater make-up and make-up to the closed compressor jacketwater system is provided by the Griscom-Russell Co. single effect evaporator. Evaporated water is also used in closed cooling systems for boiler and process area hot pump and turbine glands.

All condensate is returned to the boiler feed tank, with oily condensate having passed through an oil-water separator and Permutit Oil Removal Unit.

Steam for space heating is taken from the 90 psig. exhaust system and condensate returned to the feed tank except for a few remote locations with small steam requirements.

Water is supplied from three wells on the site, with pumps capable of providing 250 gpm. A motor driven pump (with engine driven stand-by)



Exterior view of compressor house showing interstage and aftercoolers and, right center, engine jacket water pumps. Part of the electrical system is at right

taking suction on the raw water storage tanks supplies a fire loop about the plant.

Cooling water is treated to prevent corrosion and scaling. Scaling is avoided by addition of sulfuric acid to a controlled alkalinity, corrosion with Betz "Orocol." Jacket water is treated with "Orocol," with pH control by caustic soda additions to between 7.0 and 7.5.

Two 1500 Kw, 0.70 power factor, 2400 v. 3-phase 60-cycle Worthington totally-condensing turbogenerators supply plant power. Initial design conditions call for the output of only one unit, but at operator's option it may be desirable to operate both machines. Synchronizing equipment is available also to permit load transfer without power interruption.

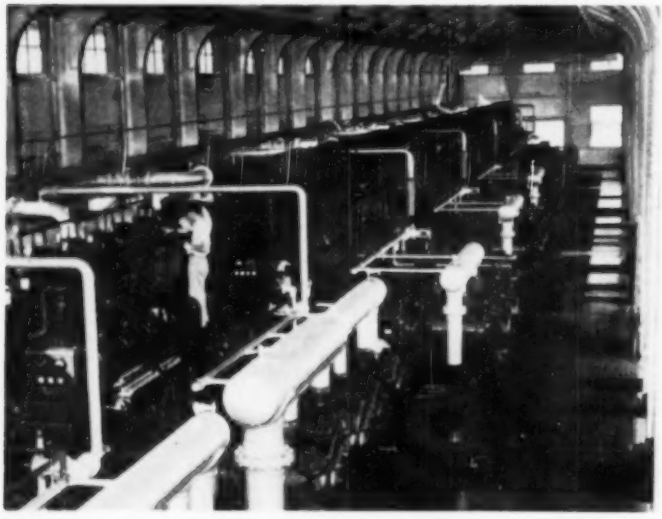
Primary 2400 v. power is distributed to two 1000 KVA 2400/480 v. unit substations and the four primary voltage motors driving the cooling tower circulating pumps. Secondary 480 v. power is distributed to the lighting transformers and to the balance of the 3-phase motors in the plant. The unit substations are the double-ended type providing normal parallel operation of two 500 KVA 2400/480 v. transformers through a single secondary bus. Provisions are made for parallel operation of both substations in event of overload or during transformer maintenance.

The Fluor 4-cell cooling tower is designed for 15,000 gpm. with design conditions of 109° F. inlet and 85° F. outlet and has a calculated heat dissipation of 155,295,000 Btu/hr.

Tankage, supplied by Chicago Bridge and Iron Co., consists of four vertical floating roof 20,000-bbl. tanks handling motor gasoline, 13 horizontal tanks of 1375 bbls. each (six handling butane and seven propane), six 1250-bbl. cone-roof vertical tanks (three for kerosine, two for fuel oil and one for miscellaneous rundown), two 1000-bbl. cone roof vertical absorption oil tanks and one 1375-bbl. gasoline rundown tank.

The loading racks of Black Sivalls & Bryson Inc. design, are capable of loading 40 tank cars simultaneously and two trucks at the truck loading station located outside the plant fence.

Major equipment suppliers not otherwise mentioned include: high pressure vessels and exchangers, C. F. Braun & Co.; compressors, Clark Bros. Co. Inc.; instrumentation, Brown Instrument Co.; most low pressure vessels, Wyatt Metal & Boiler Works; plug valves, Nordstrom Valve Co. and Walworth Co.; steam pumps, National Transit Pump and Machine Co.; centrifugal pumps, Pacific Pumps Inc.; general service pumps, Gould Pumps Inc.; large electric motors, Wagner Electric Corp. air coolers, and buildings, Braden Steel Corp.



The compressor building houses two 600 hp. and five 1600 hp. Clark compressors. The small compressors boost casinghead gas to 200 psi before processing; one of the large units is on recompressor duty while the balance handles repressure gas

Shell's New Refinery Maintenance Shop Integrates All Crafts Under One Roof

This paper was presented under the title "Layout and Operation of New Shops—Houston Refinery, Shell Oil Co." at the 15th Mid-Year Meeting of the API Division of Refining, Cleveland, May 3

By ROBERT HALDANE, Chief Engineer
Houston Refinery, Shell Oil Co.

Because of the large expansion program of the Shell Oil Co.'s Houston refinery, the maintenance shops built in 1929—which had been used with some extensions since that time—were found entirely inadequate for the maintenance requirements of a modern large-scale plant. The modern concept of a shop building is that it shall include all integrated crafts under one roof, and the Houston refinery shop was designed and built with this objective. The 216-ft. by 456-ft. building is of 3-bay construction, each bay equipped with a bridge crane.

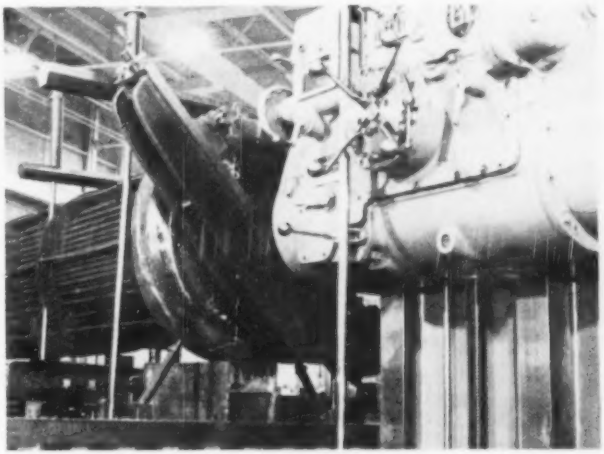
The best type of modern maintenance equipment has been installed in the shop; and, since its installation, refinery equipment which requires repairs can be handled faster and more efficiently; the quality of the work has improved; and the out-of-service time for many important pieces has decreased. The layout lends itself to the use of many types of material-handling equipment—including fork trucks for palletized material, and jib cranes for setting up equipment in the machines.

A system has been established for routing work through the shops on the basis of "short on paper work—long on expediting" and personal follow-through. The prime purpose of this shop is to reduce maintenance costs by efficient flow of equipment through the various sections, by modern machine-tool methods of repair, and by the accomplishment of more quality and precision work.

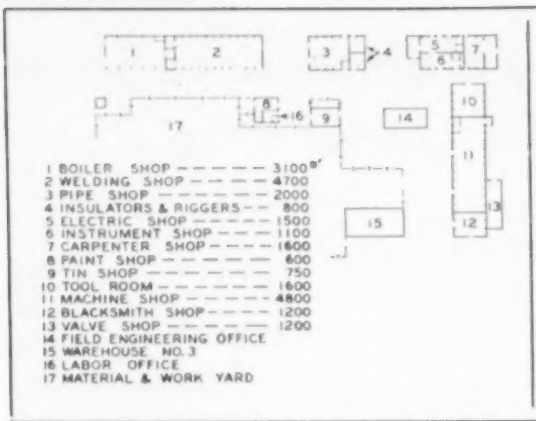
FOR some years past practically all industry has been faced with the problem of trying to squeeze out a reasonable profit from operations in which the cost of production, labor, equipment, material, and similar has increased out of all proportion to the prices obtainable for finished products. This has necessitated careful analysis of all phases of operations so that inefficiencies can be located and eliminated. Because, normally, industry's revenue is in return for the quantity and quality of products manufactured and sold, manufacturing methods are under constant scrutiny by management for possible improvement. Maintenance, however, is a very different matter. The usual tendency is to consider maintenance as a necessary evil—a stepchild, so to speak, which gets what is left of capital appropriations allocated for improvements only after the favorites have obtained their "take"—which they justify on the basis of tangible early payouts.

Such a justification is relatively easy for operations wherein it is possible to estimate the return accurately, based on improved and additional salable products. Consequently, the maintenance engineer is up against tough competition, for he must justify his capital expenditures largely on intangibles. Usually he has little difficulty convincing management that better working conditions—i.e.,

THIS MONTH'S COVER PICTURE



Shell's new maintenance shop at Houston is equipped with many heavy-duty, high-speed machine tools—so that repairs can be handled faster, better and at lower cost. Shown here is a horizontal boring mill, with a heat-exchanger bundle of considerable size in place for resurfacing of the tube-sheet face. Without such modern equipment, this job could be done only by disassembly of the entire bundle. Another time-saving advantage of these modern machine tools is that many cuts can be made on a piece of equipment with only a single setup.


1 BOILER SHOP - - - - - - 3100
2 WELDING SHOP - - - - - 4700
3 PIPE SHOP - - - - - - - - 2000
4 INSULATORS & RIGGERS - - 800
5 ELECTRIC SHOP - - - - - - 1500
6 INSTRUMENT SHOP - - - - 1100
7 CARPENTER SHOP - - - - - 1600
8 PAINT SHOP - - - - - - - 600
9 TIN SHOP - - - - - - - - 750
10 TOOL ROOM - - - - - - - 1600
11 MACHINE SHOP - - - - - - 4800
12 BLACKSMITH SHOP - - - - 1200
13 VALVE SHOP - - - - - - - 1200
14 FIELD ENGINEERING OFFICE
15 WAREHOUSE NO. 3
16 LABOR OFFICE
17 MATERIAL & WORK YARD

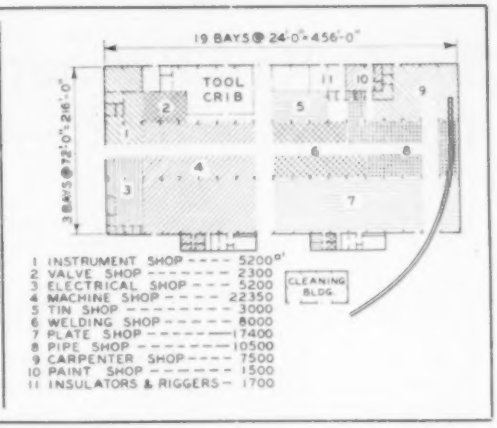

19 BAYS @ 24'-0" = 456'-0"
TOOL CRIB
CLEANING BLDG.
1 INSTRUMENT SHOP - - - - 5200
2 VALVE SHOP - - - - - - - 2300
3 ELECTRICAL SHOP - - - - 5200
4 MACHINE SHOP - - - - - 22350
5 TIN SHOP - - - - - - - - 3000
6 WELDING SHOP - - - - - - 8000
7 PLATE SHOP - - - - - - - 17400
8 PIPE SHOP - - - - - - - - 10500
9 CARPENTER SHOP - - - - 7500
10 PAINT SHOP - - - - - - - 1500
11 INSULATORS & RIGGERS - 1700

Fig. 1 (left) and Fig. 2 (right)—the old and the new. The old shops area included only 26,000 sq. ft. of shops, scattered within an area of some 375,000 sq. ft. In the new Shell maintenance shop, practically all activities are centralized under one roof—with 98,000 sq. ft. of net floor area

adequate lighting, pleasant surroundings, air conditioning, and similar—improve morale and worker efficiency. However, the question always is: how much improvement?—and it had better be plenty, for therein lies the payout for the improvements! Certainly, process and product improvements must be taken care of, because ultimately they determine the income. This is as it should be; but it is also easy to neglect, or to overlook, the possibility of improvements in maintenance—which are of equal importance.

By "equal importance" is meant that the gains which result from product improvement, or from improved manufacturing methods, may be offset by higher maintenance costs. Improved maintenance facilities result in a leveling off of the trend toward higher maintenance costs—even an actual reduction in such costs. Shell's management became aware of this situation, and it was this awareness which resulted in their approval of complete new facilities to replace those which had been in service since 1929.

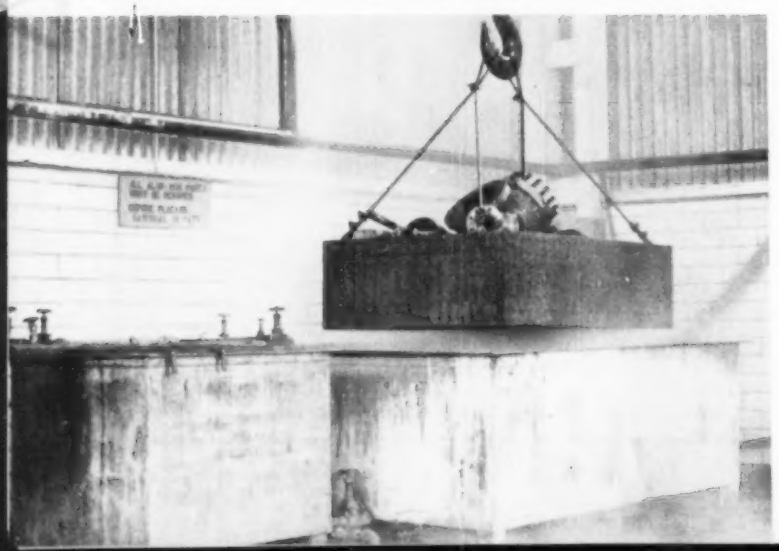
Need for Shop and Offices

Shell Oil Co.'s Houston refinery was originally constructed in 1929 for a crude intake of 26,000 b/d, and the shop facilities were designed to support a refinery of that capacity. Since that time the refinery's capacity has practically quadrupled—with an increase of approximately 25% in shop space and capacity. The old shops and working spaces were scattered within an area of some 375,000 sq. ft., as indicated in Fig. 1. Included in this was a total shop area of 26,000 sq. ft., with the remainder consisting of outside working space. This was entirely unsatisfactory for the job at hand.

Furthermore, the movement of material and equipment to be repaired proceeded in a cumbersome, time-consuming, and expensive manner. Devices such as wheelbarrows, scooters, trucks, and similar were used to transport equipment and material from one shop to another. This resulted in very unsatisfactory job planning and scheduling. In many instances it was necessary for field supervisors to follow a piece of equipment from one shop to another so that they could be sure it was being worked on. Thus their valuable time was wasted which could have been utilized to better advantage elsewhere.

In the new shop all maintenance activities are included under one roof with the exception of the labor department, which requires space only for supervisors' offices and laborers' equipment such as shovels, picks, weed cutters, and similar, and the cleaning building. With the exception of the electronics room (in the instruments section) and the paint room, there are no partitions between the craft areas. The reason for this is to permit observation of the entire shop from any point, so that the handling of materials and equipment may be facilitated, and so that flexibility of the craft areas may be provided as it is needed.

To keep to a minimum the amount of dirt and oil brought into the shop, all dirty equipment is routed to a separate cleaning building as it comes in from the field. Here it is cleaned by dipping in a solvent bath (as shown below) or sandblasted



Description of Shop

The main shop building is of structural steel and corrugated transite, with an 8-ft. wainscoting of buff brick; it has a flat roof. The build-

Fig. 2—Exterior view of the new maintenance shop, with separate cleaning building at right

ing is air-conditioned throughout. Overall dimensions are 216 ft. by 456 ft. There are 98,000 sq. ft. of net floor area, including interior offices and drives. Actual shop space approximates 82,000 sq. ft., of which 12,000 sq. ft. are allocated to heavy storage.

Illumination is by combination mercury-vapor and incandescent lamps. There are continuous hammered-glass lights in the upper section of the north and south walls only. The east and west walls, which are long, are without glass so as to guard against sun-ray eye strain.

The three bays in the building are 72 ft. wide, each equipped with a bridge crane. In two of the bays the inside clear height to the roof is 34 ft., and in the third bay it is 24½ ft. Two identical extensions on the east side contain foremen's offices and separate washrooms for foremen and craftsmen. Offices for other supervisory personnel are located adjacent to individual craft areas within the building.

One building, which is used with the shop itself, is separate from the main building; this is the cleaning building. It has the same architectural treatment as the main shop building. It is not air-conditioned, but is heated by warm-air circulation. The overall dimensions are 40 ft. by 80 ft., with 3,000 sq. ft. of net floor area. There is a 15-ton bridge crane on rails, 18 ft. above the floor level.

Fig. 2 illustrates the plan of the interior of the shop-building and Fig. 3 shows the exterior of the area.

Lighting

A light intensity of 35 foot candles at floor level is provided throughout the shop by 222 750-watt incandescent lamps, and the same number of 400-watt low-pressure mercury-vapor lamps mounted in pairs at the bottom chord of the roof trusses. The mercury-vapor lamps are useful for reducing the glare from the incandescent lamps, because of their relatively large area of light source and consequent low brightness. Their characteristic "shadowless" illumination is particularly helpful when metal surfaces are being worked on. The offices, as well as the training, electronics, and paint rooms, are illuminated by fluorescent lamps which provide a desk-level light intensity of 50 foot candles.

Paint Room

A water-spray booth, with a working volume 10 ft. wide, 8 ft. deep, and 7 ft. high, is installed in the paint room. The circulating-water system removes the undeposited paint from the booth exhaust—thus preventing its dissipation outside the shop building. The booth opening is provided with a filter to remove dust from the incoming air. Adjacent to the spray booth is a 12 ft. by 18-ft. drying room in which batteries of incandescent lamps are used for the rapid evaporation of solvent.

Cleaning Building

The primary purpose for providing a cleaning building is to reduce to a minimum the amount of dirt and oil brought into the shop building along with the work. When they require any cleaning, all pumps, heat exchangers, motors, castings, and similar are routed to the cleaning building before they are taken into the shop.

A 6-ft. diameter dipping vat, 17 ft. deep, is recessed in the floor for the cleaning of heat exchangers, pumps, and large castings. Facilities are provided within the vat for circulation of liquid solvent, and for rotation of the article being cleaned. Smaller vats are also available for cleaning. A sandblasting chamber, 11 ft. by 15 ft. is equipped with a sand-and grit-recovery conveyor, elevator and filter, a dust exchanger, as well as automatic filling of the sandblasting machine. All equipment is handled on dollies or by means of a 15-ton floor-operated bridge crane.

Shop Equipment

The shop is equipped with the most modern machinery available. Much of it is standard maintenance shop equipment, but there are a few items which deserve particular mention.

Because of the fact that there is so much rotating equipment in the plant—such as turbines, centrifugal pumps, blowers, electric motors, and similar—the need for dynamic balancing equipment justified the installation of two Gisholt dynamic

Meet the Author

Mr. Haldane

Robert Haldane, chief engineer of Shell Oil Co.'s Houston refinery, received his B. S. degree in mechanical engineering from New York University in 1929 and was first employed by Shell in 1930 as a gager in the Dubbs' plants. He advanced through such positions as cracking-plant inspector, and technical assistant in the cracking department; and in 1934 joined the engineering department to handle problems in lubrication, estimating and field construction. In 1936, appointed utilities engineer, he was in charge of operation and maintenance of boiler and power-house, cooling and domestic water systems. In 1942, on military leave, he became an aircraft maintenance officer, and was assigned to the U. S. Air Mission to Bolivia. At the war's end he returned to Shell as assistant chief engineer in charge of maintenance and was later promoted to his present position.

Fig. 4—Little paper work is required to move a piece of equipment through Shell's maintenance shop. A "Job Identification" tag is attached to the piece before it goes to the shop, and at the shop it gets a "Shop Route" tag. The latter tag is red, yellow or green, the different colors indicating various levels of priority

balancers. Experience with this equipment to date indicates that bearing failures, excessive vibration, and undue wear may be reduced or delayed by having the rotors balanced on the initial installation after a maintenance overhaul. Of course, it is recognized that, because of the corrosive nature of the products which are pumped and of the possibility of scale on the turbine blading, rotating equipment will not remain in balance; however, with a good balance to start with, the need for overhaul resulting from these conditions may be delayed, or the time between overhauls may be lengthened.

A cylindrical grinder was also installed, and is capable of grinding the surface of an 8-in. plug cock in 1½ hrs.; the old method, which used a grinding attachment on a lathe, took approximately 6 hrs. In a refinery of this size there are numerous valves and plugs which require grinding. Furthermore, many pieces of equipment are hard-surfaced so as to provide wearing quality, and these are also ground on this machine.

Another piece of equipment which is more than paying its way is the horizontal boring mill. With this machine many cuts can be made on a piece of equipment with only a single setup. To set up a machine of this type is exceedingly time-consuming, and anyone familiar with this will appreciate the savings involved.

The foregoing represent three examples of what we are doing in the machine section to improve maintenance and to decrease maintenance costs. Numerous other examples might be given to illustrate similar savings resulting from the use of modern equipment in all the other sections.

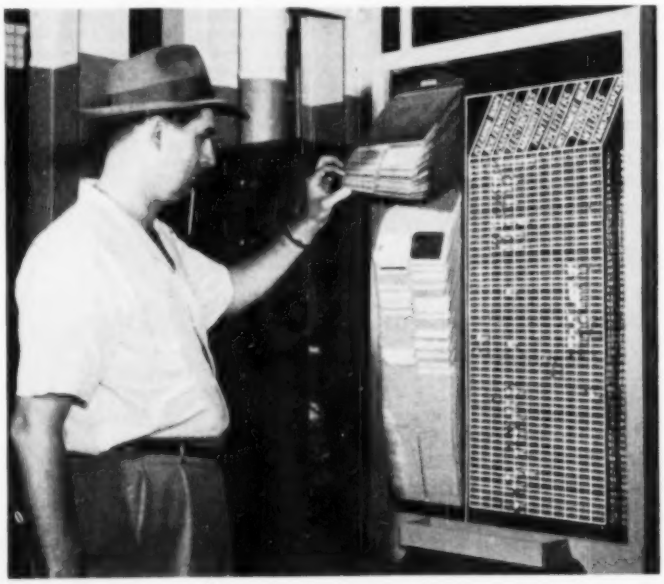


Fig. 5—This job control board, maintained by the shop expediter, shows the status and location of all jobs which flow between individual sections in the shop

Material Handling

The greatest advantage of having all shops under one roof, without partitions, is in the handling of equipment and materials. As has been mentioned previously, in the old shops the handling of equipment and materials was extremely inefficient. In order to eliminate time-consuming materials-handling inefficiencies, modern handling equipment has been provided.

Several types of equipment for handling materials are available. As mentioned previously, a traveling bridge crane is provided in each of the three bays. These are of 15-, 10-, and 5-ton capacity, and they operate the full length of the building on independently supported rails; the two larger cranes are both cab- and floor-operated, whereas the 5-ton unit is floor-controlled.

Throughout the building are located 20-ft. and 30-ft. electric-hoist 1-ton jib cranes, pivoted from the crane columns, where frequent handling of light materials and equipment is required. There are 13 cranes in place, and provision is made for future additions as required.

A gasoline-powered fork-lift truck is available for handling pallet and medium-weight material from bay to bay, and for delivery and loading of finished work.

Numerous small bins are constructed so that they can be handled either by the fork-lift truck or by the cranes. All the material for a specific job which conveniently can be placed therein is put into one of these bins for transport to the job site. These bins are used to hold all the disassembled parts of a pump, turbine, or any other piece of equipment on which work is being done. Other types of bins are used in the welding section; these are designed so that they will sit one on top of the other for the purpose of holding fabrication parts such as flanges, welding ells, tees, and similar.

The load luggers used in the refinery are employed for the collection of scrap and waste in the building. Pans are placed in the craft areas where they will be accessible for removal by the truck. The sawdust and shavings from the carpenter-section cyclone collector are deposted in an enclosed-type pan for periodic disposal.

Shop Job Expediter

All of this new equipment, and the money expended for it, will not provide better and lower-cost maintenance unless advantage is taken of the most modern materials-handling methods and shop coordination.

Prior to the completion of our shop, several of our staff personnel visited a number of job shops throughout the country for study and analysis of the scheduling, planning, coordinating, and expediting methods used. Many excellent systems were studied, but the majority of them are not suitable for a refinery-maintenance shop, because the time which they allow for the preparatory work incident to the starting of a job usually is longer than an oil refinery can provide for the entire job itself. Furthermore, the success of all these systems depends on the individual who is responsible for their administration or, as he is usually called, the job expediter. What is required is an eager young man with the know-how—and a "burr under his tail." This is what we have tried to obtain—a job expediter who is "short on paper work —long on expediting." His overall responsibilities include:

1—Upon receipt of a job in the shop, he expedites and controls the flow of the job between shop areas. He keeps himself informed at all times as to the status of every job which moves through more than one shop.

2—Upon completion of the work on a job, he arranges for and expedites the movement of the job to the proper field site. Automotive equipment is available to the expediter for the most efficient handling of all materials, as needed.

3—He orders necessary materials from the warehouse, and requests their delivery at the proper time.

4—He receives all materials which come into the shop, and he dispatches them to the proper craft areas.

Effective coordination, which is designed to keep the work flowing through the central shop at all times, requires cooperation with the shop expediter of the individual shop foremen, zone supervisors, and field foremen. The shop expediter is notified of all special or unusual requirements which may arise, so that the most efficient control of the work will be had at all times.

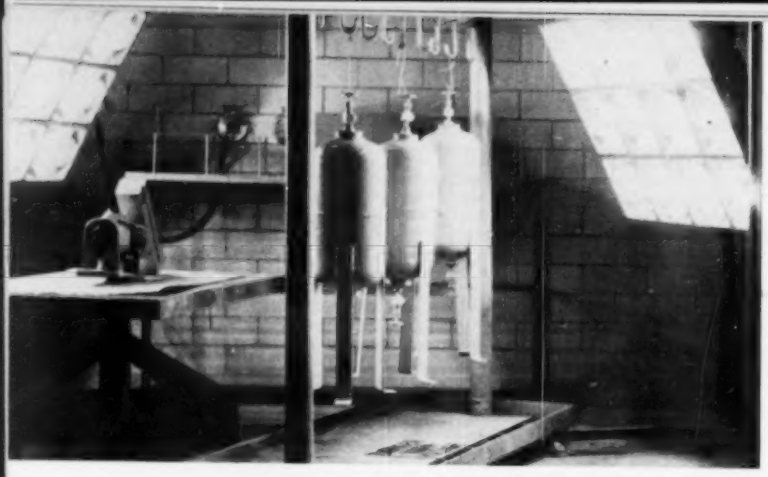
General explanations and clarifications are as follows:

1—The identification tags used by field foremen or zone supervisors to tag jobs going to the shop are buff-colored (Fig. 4). Upon such a tag is written the job order number; equipment number; brief explanation of the work to be performed; sections through which the work must flow—listed in order of necessary sequence of work and priority of the job; and some indication as to where the completed job is to be delivered. This tag is not intended to carry every detail of a specific job. Additional information is given to various shop foremen by phone and, if necessary, it is supplemented by sketches or prints.

2—The shop route tags (also shown in Fig. 4) are filled in by the shop expediter as soon as he receives the job from the field, or when he receives by phone additional required information from field foremen or zone supervisors. Jobs are divided into No. 1, 2, and 3 priority —identified, respectively, by red, yellow, and green tags. Normally, No. 1 priority is considered an emergency, and it is used only when there is an actual emergency. No. 2 priority is considered urgent, and it

ACTIVITY PROCESS
JOB FLOW
Area Supervisor or Field Foreman
1 Fills out identification tag and tags job going to shop.
2 Arranges for transportation of job to shop.
3 Gives necessary additional information to craft foreman or expediter.
To central-shop receiving area or cleaning room by truck.
Shop Expediter
Temporary storage in central-shop receiving area.
4 Receives additional necessary information by phone from supervisor or field foreman.
To receiving area of craft where first work required - by lift or crane.
5 Removes identification tag and fills out and attaches shop route tag.
Temporary storage in craft receiving area.
Craft Foreman
6 Removes route tag to get information and to keep tag from being destroyed.
To work area or machine - by fork lift or crane.
9 Necessary work on job performed by craftsmen.
Shop Expediter
7 Orders all materials necessary for repairs or fabrications.
To craft outgoing area - by lift or crane.
8 Receives all incoming materials and dispatches to proper shop area.
Temporary storage in craft outgoing area.
Craft Foreman
10 Tears bottom stub of tag, records time work completed, and places stub in completed job box. Replaces tag on job.
To next craft receiving area shown on bottom stub of tag.
Temporary storage in craft receiving area.
(Repeat part of process from operation No. 5 through above temporary storage until job goes through all crafts necessary for completion of work.)
Shop Expediter
11 Periodically reviews status of all jobs; keeps job-flow control board up to date.
To central-shop outgoing area.
Shop Expediter
12 Determines and arranges for best available transportation.
Temporary storage in central-shop outgoing area.
To proper field site.
AN OPERATION
A TRANSPORTATION
A STORAGE

Fig. 6—Flow diagram of the movement of work through the shop



Paint drying room, equipped with batteries of lamps

includes normal shutdown jobs or jobs which have a time limit. No. 3 priority is considered routine, and it is confined to routine jobs.

This establishhment of priority is handled as conscientiously as possible, and with the utmost cooperation of field foremen and supervisors with the expediter.

3—The shop route tags carry three stubs, which are filled in by the expediter; they show the expected route of a specific job. The outside stub designates the section where work on the job will be performed first; the middle stub designates the section where the next work is to be performed; and the inside stub designates the third section where work will be performed.

If work on a job is to be completed in less than three sections, unused stubs are left blank. If more than three sections are to work on a job, two tags should be used—with the second tag showing fourth, fifth, and sixth sections. Upon completion of a job in one of these sections, a craft foreman removes the stub which designates this worker's craft, and he records the time of completion. This stub is retained by the craft section, and it is accessible in the event the expediter should desire to review all stubs. Thus at any time he may know the status of all jobs.

The expediter also maintains a job control board, which shows the location and the status of all jobs which flow between individual sections. The control board is shown in Fig. 5.

4—If for any reason it becomes necessary for a job to be moved between craft sections contrary to the route shown on the tag, the craft foreman notifies the expediter so that a new tag may be made up and the expediter's record of route can be revised. If unexpected work arises which requires routing of the job to additional sections, any blank stubs left on the tag are filled in by the craft foreman who handles the job, and he then notifies the expediter of such additions.

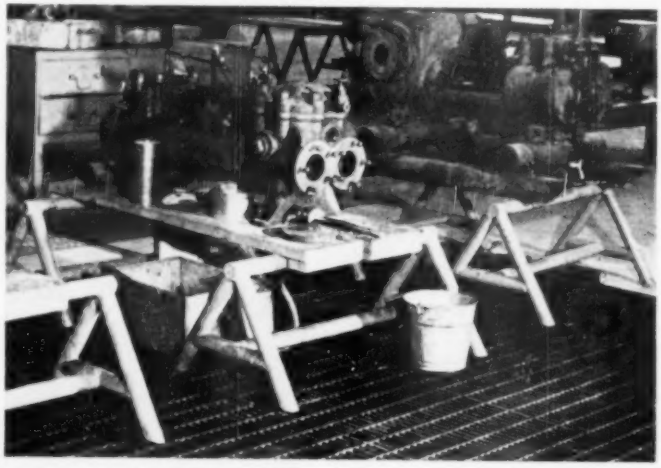
If work is to be done on more than one unit of equipment under a single job order number, each unit carries a separate tag; and the job order number is followed by the letters "A," "B," etc., to identify each separate unit. If equipment is broken down into several different units after it has entered the first section, the expediter is notified so that he can properly tag each unit and revise his job and route record.

5—A central-shop receiving and dispatching area is designated in a central location. Each craft section has similar receiving and outgoing areas. It is the responsibility of the various craft foremen to expedite the movement of jobs from the craft receiving area to the work area, and from the work area to the craft outgoing area. It is the responsibility of the expediter to see that these jobs move quickly, and in the most efficient manner, from the craft areas, as well as from the central shop, to the proper field sites. Fig. 6 is a flow diagram of the movement of work through the shop.

Fabrication Work in the Shop

It should be clearly understood that we are here concerned with a maintenance shop—not a fabrication shop. The primary purpose of the construction of this unit was to increase maintenance efficiency through decreased cost. This is not to say that no fabrication work will be done. The manpower requirements of a refinery of this size are based on the personnel needed to handle the major plant turnarounds. Usually one of these turnarounds occurs each week, so that, in general, maintenance forces are continuously occupied. However, there are slack periods when some of the members of the various crafts are not fully occupied. It is for these slack periods that a certain amount of fabrication work is planned.

We recognize that we are not set up for production-line fabrication, although we can closely approximate it; and many articles can be fabricated on a competitive basis. However, such fabrication results in a saving of out-of-pocket expense to the company, because the labor expended may be considered an overhead item. Even if the labor and material expended were greater than the cost of a purchased item, there would still be a saving if we did the fabrication by making use of this



Pumps brought in for maintenance and repairs are disassembled in a special area, with a pit provided for catching pump drainings—another effort to maintain good housekeeping in the shop

overhead labor. However, when we hire personnel for the purpose of fabrication, we are out of the oil business and are in the machine-shop business—and this, of course, is not our purpose.

Manpower Requirements

Our craftsmen, for the most part, are trained in our own plant through on-the-job upgrade training. Each man, as he steps up in classification from helper to first-class mechanic, must meet specific and established quaifications. He is given adequate opportunity to become qualified through a diversity of job assignments. A certain amount of preparatory academic work is given, on company time, to prepare helpers for the work training. By these means we have been quite successful in obtaining qualified craftsmen.

It is difficult to evaluate, in terms of dollars and cents, the actual returns of an installation of this type. Of course, there is one way of evaluating it: If tools are used in the most efficient and effective manner, the number of men required to do the work is reduced; thus a decrease in payroll should result. Furthermore, modern shop equipment makes possible quality and precision work, so that failures should occur less frequently. This also may be reflected in reduced manpower. However, the real payout on a project of this sort lies in getting back into operation those units which are out of service for maintenance—thus considerably reducing downtime.

THE FOREMAN IN MAINTENANCE

Duties and a Method of Grading

The principal portion of a paper of the same title, presented at the 15th Mid-Year Meeting of the API Division of Refining, Cleveland, May 3

By *ROBERT L. RUDE, Sun Oil Co., Philadelphia*

The non-repetitive nature of maintenance work in refineries makes it difficult to attain the efficiency reached in production work. However, it can be improved through the proper standardizing, scheduling, and planning. The foreman directly over the workman who uses the tools is the vital link in line management, and he can make or break any plan designed to increase plant maintenance efficiency. A procedure is described for evaluating foremen to determine their capacity to develop the necessary characteristics and abilities for maintenance work.

IN THE manufacture of merchandise we have two basic principles; one custom built, the other mass production. There are varying degrees to which these two principles can be applied. At one extreme we find custom-built products made by a few skilled craftsmen who have the knowledge and skill required to perform all the processing steps from the raw material to the finished product. At the other extreme we find workmen on a production line who are highly skilled and proficient in doing a few restricted operations over and over again.

A specific operation which may take hours to perform on custom-built merchandise may be reduced to a matter of seconds in a production-line operation. The tools supplied the workman, and the skill he develops in doing a highly repetitive operation, are responsible for the reduction in time and cost.

The achievements which have been attained in the field of mass production have been most gratifying. But when we try to extend this principle into the field of repair and maintenance of equipment, the results as a rule have been most discouraging. Tools and people are the two components in any industrial enterprise which process materials. Tools and people are also the two components utilized to repair and maintain the processing tools. Why is it more difficult to use tools in one case than in the other?

On the production line the mental effort load of the workman has been skillfully reduced to such a degree that he complains of monotony. His principal concern is in developing the manual skill required in doing a specific and highly repetitive operation. A group of experts is employed to do the thinking.

On maintenance, the mental effort load of the workman has not been reduced by technological advancements. On the contrary, it has been increased. The variety and complexity of design of new apparatus, and of operating conditions of the apparatus, have all combined to increase the mental effort load of the maintenance mechanic. The job demand for this mechanic to have the capacity to think and reason, to weigh cause and effect, is going up—not down.

He may have a dozen pumps of the

Meet the Author

Mr. Rude

Robert L. Rude, assistant to the vice president in charge of manufacturing for Sun Oil Co., has been identified with petroleum refining since 1920, when he started with Sterling Oil and Refining Co., at Wichita, Kans. In 1925 he joined M. W. Kellogg Co., Jersey City, N. J., as an operator and later became an engineer. Mr. Rude was with the British-American Oil Co., Ltd., Canada, from 1931 to 1945, first as a refinery superintendent and then as general superintendent of refineries. He has been with Sun since 1945. As a result of his work on cracking and distillation units, he has written a number of articles for technical publications and several patents have been issued in his name covering methods and means of processing flowing liquids.

same size and design under half a dozen different operating conditions. This will result in different wearing characteristics and maintenance problems. How much room he has in which to do his work, area conditions, safety precautions necessary and, in some cases, the special clothing he must wear, all contribute to variety and complexity in job demand for skill and knowledge which the mechanic must practice.

A maintenance mechanic may make a repair to a pump which will take him an hour. A month later a similar repair to the same pump may take two hours. In the second instance the mental effort in exercising skill and knowledge may considerably exceed that of the first instance. The question of greatest importance is: Will the repaired equipment stand the test of operating conditions—not did the mechanic spend one hour or two hours in making the repairs.

The vast difference in job demand of a workman on a production line and a workman in a maintenance craft is easily seen. It is also obvious that it will never be possible to attain the efficiency in the field of maintenance and repair of refinery equipment which is common to production-line operations. But, in reconciling ourselves to this fact, we should not lose sight of two questions: First, has our use of tools and people in plant maintenance reached as high a degree of efficiency as we have a right to expect? Second, are we utilizing the basic principles of standardizing, scheduling, and planning maintenance work to the highest practical degree?

This is where the foreman enters the picture. We have a pretty good idea of the contributing factors affecting the variety and complexity of the workman's duties. Let us take a look at the job demand of a foreman in refinery maintenance and see what constitutes his duties.

His duties are also concerned with tools and people, but from an entirely different approach from the mechanic's. His job demand for skill and knowledge in dealing with people has been given top priority in the literature on this subject for a number of years. Let us analyze it a little and see if we can agree on the essential elements which dominate this phase of his job demand.

Knowledge in dealing with people should include:

1—The rights of the employes established by law and company policy: There are numerous privileges which employes enjoy which have nothing to do with government statutes.

2—The basic fundamental principles affecting the functioning of people in enterprise: These principles have been defined as : *a*—frankness and honesty in dealing with people; *b*—treating others as you would like to be treated; *c*—faith in a man to perform the duties assigned to him which have been determined are within his capacity to execute.

3—The other crafts of maintenance, and a fair understanding of their problems; the operation and service departments and what makes their jobs more or less difficult.

It is not enough for a foreman to possess the knowledge of the functioning of people in enterprise; he must have the skill required to reduce this knowledge to practice. The essential elements making up job demand for skill in dealing with people have been broken down into:

1—Capacity to lead others: The fear of being fired is no longer the stimulus which prods a workman to perform his assigned tasks. The practice of driving men has given way to skill in leading them.

2—Capacity to teach others: The ability to teach workmen is not confined to detailed use of tools, but includes imparting knowledge regarding the functioning of people in enterprise. This includes knowledge regarding other crafts, operations, and service departments.

3—Capacity to cooperate with others: To coordinate the functioning of his group with others to effect team work; to make an effort to understand and make allowances for the problems of other foremen.

A foreman cannot know and understand the rights of employes unless he knows something about the history and growth of employer-employe relations at least as far back as the start of the mechanical age. Skill in teaching and leading others requires ability to reason and analyze problems with them, thereby stimulating them to use their own powers of reasoning.

Why is it so important that foremen meet their job demand for skill and knowledge in dealing with people? Because the tools of enterprise are controlled by workmen—and how the workmen use these tools depends upon their attitude. The workman's attitude toward his tools, fellow workmen, toward management and enterprise in general, is most directly influenced by his foreman.

Evaluation Procedure

We have devised a procedure for evaluating a foreman. The procedure serves two purposes: First, it has been utilized to evaluate foremen and acquaint them with their weak spots. Second, it has been utilized to evaluate prospective foremen in order to determine whether they possess or have the capacity to develop the characteristics and abilities which the job will demand of them.

An important step in the evaluation of a foreman, or a prospective foreman, is to determine the qualifications of the evaluator. This is determined by each evaluator's filling out the following questionnaire:

1—How long have you known the foreman?

2—Has your knowledge of facts required to evaluate him been gained by: *a*—observations; or *b*—by discussing his job with him?

3—Is your judgment of the foreman's knowledge and skill relating to tools, equipment, and material based on: *a*—personal observation; or *b*—hearsay?

4—Is your judgment of the foreman's knowledge and skill in dealing with people based on: *a*—personal observation; or *b*—hearsay?

5.—Do you consider that your knowledge is sufficient to qualify you to evaluate the foreman:

a—In the particular type of skill related to the tools of the craft?

b—In the particular problems in dealing with people which arise in the performance of his duties?

A study of this questionnaire reveals that it not only disqualifies the uninformed, but supplies information which can be of considerable assistance to the one conducting the evaluation.

After a qualified committee has been chosen, the next step is to evaluate the man. The following procedure is utilized for this purpose:

1—Knowledge of a type which can be gained without practical experience:

a—Of principles and procedures.

b—Of material and equipment.

2—Knowledge which can only be gained through practical experience:

a—In dealing with tools.

b—In dealing with people.

3—Skill in dealing with tools:

a—Resourcefulness and initiative in coping with emergencies and abnormal situations.

b—Creative thinking in devising methods and means of doing the job better.

c—Judgment and efficiency in doing scheduled routine duties.

4—Skill in dealing with people:

a—Capacity to lead others (which can only be determined by whether his leadership is followed).

b—Capacity to teach others.

c—Team work, cooperation, and coordination of activities with others who have no authority over one another.

5—Accountability: Extent to which he is depended upon, relied upon, checked or supervised in practicing the foregoing skill and knowledge.

6—Mental traits and ability: Men-

tal discipline, ability to think and reason, to acquire knowledge, to adapt himself to changes in conditions and equipment.

7—What do you consider his most significant traits, characteristics, and habits?

The basis upon which numbers are developed is through discussion by the committee of the man's standing with respect to each of the sub-factors. If their pooled opinion develops that the man evaluated has all or more than his job demands of him for the particular item in question, they rate him at 100. If, in their opinion, he falls short of his job demand, they decide on a number less than 100 to indicate the relative order of shortness.

After a few factors have been evaluated, a pattern will be established. It is then a question as to how the new numbers fit into that pattern, and whether the pattern properly portrays the committee's views and opinions. The most important word in conducting the evaluation is "why." When the evaluator is required to give reasons, it is not difficult for the rest of the committee to determine whether the reasons are supported by fact or fiction.

The first five factors are based entirely upon what the job demands of the man. Factor No. 6 is utilized to determine, within the judgment of the committee, whether the man has the mental capacity to acquire the skill and knowledge required to correct his shortcomings. This item is concerned with the man's potential capacity, and it should be scrutinized most carefully. A prospective foreman should rate 100 for this item before he is advanced. An existing foreman who does not rate 100 certainly should not have his responsibilities increased.

Factor No. 7 will shed some light upon the man's characteristics which have influenced the evaluator in making his appraisal. It may also be used to acquaint the man with characteristics and habits which annoy others, as well as characteristics which people like and admire.

Functioning of Foreman in Maintenance

In evaluating the foreman's individual ability against his job demand, we have had to analyze the relative demand for skill and knowledge in dealing with people against dealing with tools. In exploring the maintenance mechanic's job demand, we found that the circumstances under which he is called upon to exercise skill and knowledge vary widely. It rarely occurs that he can be assigned to a task in which he does the same thing over and over again, hour after hour, days on end, on substantially the same material, and under constant working conditions.

Yet we should like to attain as high a degree of efficency as possible in the functioning of tools and people in maintenance. In the production line a good deal was accomplished through reduction of the mental effort load on the workman. We found that there is a great deal in the variety and complexity of tools and operating conditions which will keep the mental effort load of a maintenance mechanic at a pretty high level.

However, is it necessary to add to this load through lack of standardization, scheduling, and planning work? Is it necessary for the mechanic to stand around while the equipment is being prepared for him to work on? Is it necessary that he habitually be called off jobs half completed? Is it necessary that he be held up through lack of material, or from any one of a dozen other causes which proper organization and planning of work should eliminate?

"Oh," you may say, "we have a special department set up to take care of all these details." That's fine; but, if the foreman directly over the man who uses the tools does not figure in as an integral part of the functioning of that department, you are going to find some well-laid plans yielding some very disappointing results. It is the foreman who is first to learn why the plan does or does not work. It is the foreman who has to persuade the workman to make the plan work.

Foreman Leadership

A lot has been said and written in recent years on the subject of incentive plans. They all seem to have a dollar-and-cents approach. There is another approach which is worthy of our serious attention. This approach is effective leadership. The primary accomplishment hoped for, through the installation of any incentive plan, is to inspire the workman to use his brain to the profit of enterprise.

The take-home pay certainly has to be considered, but not to the exclusion of all other considerations. General Motors conducted a letter-writing contest among its employees. Some 175,000 employees took part. The following excerpts are from two of the letters:

"A drop-forge operator is a peculiar sort of Joe. He has a tough job and he is proud of it. He makes forgings 8, 9, or 10 hours a shift. After work he makes them in the tavern; he makes them at the dinner table. In fact, he makes them wherever and whenever he can get anyone to listen, and always makes them better than any other guy."

The second one read:

"I have a good foreman, and for every reason that I think he is good, I like my job just that much better. He thinks I have more ability than I think I have, so I consistently do better work than I thought I could do."

The incentive created by pride of accomplishment, pride of workmanship, and the exhilaration which a man gets from a tough job well done, cannot be bought. Nor can it be attained in spite of poor leadership practiced by the man's foreman.

The ingenuity of the human mind to figure out ways and means of using tools to overcome obstacles, to do a job better, or to produce better things for better living, is something our advertising agencies will not let us overlook. But we should not overlook the fact that, in this complex family we call an industrial enterprise, the ingredient which stimulates, inspires, and fertilizes the human mind in the practice of ingenuity is leadership.

Remember, it is within the capacity of the human mind to be just as ingenious in destruction and waste as in production and efficiency. Therefore, effective and ineffective leadership both have their rewards.

We are told by a considerable group of self-acclaimed authorities that leaders are born, not made. This group always fails to point to some specific examples in which they have made a determined and diligent effort to make leaders.

Psychologists tell us that leadership consists of habits and skills acquired by practice. In this respect it does not differ from any other skill which we may have acquired through patient and persistent expenditure of time and energy. A lot of that time and energy has to be spent in thinking and analyzing cause and effect. This is not such a simple or easy pastime, and it is up to management to endorse and support a program designed for this purpose.

Effective leadership has individual characteristics peculiar to the person who practices them. For this reason leadership can only be judged by whether the leader is followed. The methods employed by one, in the successful attainment of leadership, may be as ill-fitting and grotesque when used by another as the clothes he wears. Therefore, don't try to "strait-jacket" the program and sterilize it with lines and verses to be memorized.

Management is in a position to point with pride to what has been accomplished with tools in the field of maintenance in the past 30 years. A lot of creative thinking, research, and development has taken place in this field. Is management in a position to point with equal pride to the creative thinking, research, and development regarding the functioning of people in maintenance?

Effect of Sulfur on TEL Requirements Less by Road Than by "Lab" Ratings

Condensed from a paper titled "Road Effectiveness of Tetraethyl Lead as Influenced by Added Sulfur," presented at the 15th Mid-Year Meeting of the API Division of Refining, Cleveland, May 4

From a Report by DONALD H. PULLEYBLANK *and* WHEELER G. LOVELL, *Ethyl Corp. Research Laboratories, Detroit*

THE difference between road and laboratory knock rating results may lead to errors in determining changes in tetraethyl lead requirements due to changes in fuel sulfur content, if laboratory results are used as a criterion of road anti-knock values.

This conclusion was reported by technologists with Ethyl Corp. Research Laboratories, in Detroit, to the Motor Fuels Session May 4 of the API Refining Division in Cleveland.[1] It is based on studies carried on by the Ethyl laboratories in which the effects of added sulfur in 11 current commercial fuels containing TEL were investigated in laboratory knock-test engines and in current model automobiles on the chassis dynamometer. According to the road data, the changes in TEL required, and the loss of octane number, are only about 50% of these indicated by the laboratory knock-test engine data, it was reported.

"Addition of 0.01 to 0.12% sulfur to 11 current commercial fuels gave average reductions of about 1 to 2 octane numbers", it was stated. "The sulfur compounds were less deleterious to the anti-knock effect of TEL in road tests than they were in either Motor or Research Method laboratory tests. Knock ratings with some combinations of fuels and cars were unaffected by the added sulfur.

"Separation and maldistribution of fuel components in the automotive-engine induction system may explain part of the difference between road and laboratory results. The cases in which sulfur had no effect cannot be explained by this phenomenon.

"The average effectiveness of sulfur against TEL anti-knock action was about the same in all except one of the cars tested.

"The 11 fuels examined were free of hydrogen sulfide and mercaptans, and they contained only a trace of free sulfur. Their average sulfur content was 0.09% by weight, and the average laboratory TEL efficiency was estimated to be 46%."

The experiments described in the paper were conducted by the Ethyl Corp. laboratories to obtain information on the effect of the common types of sulfur compounds on the anti-knock value of a variety of modern fuels in current model automobiles, and to provide a comparison with the effect of sulfur as measured in laboratory knock-test engines. The test procedure in general, therefore, was to add small amounts of sulfur compounds to leaded gasolines, and to determine the knock ratings of the fuels in both laboratory knock-test engines and also in automobiles.

Eleven regular and premium grade gasolines were selected as being representative of fuels currently marketed, and lead-free samples of these stocks were obtained. A heptane-isooctane blend was included for comparison. The fuels were blended with the current commercial ethyl fluid to provide contents of 0.0, 0.5, 1.5 and 3.0 ml TEL/gal. These blends were rated by the Research and Motor knock-test methods. They also were rated in cars on the chassis dynamometer by the modified Uniontown knock-test method, which has been found through years of experience to give knock ratings in excellent agreement with those from actual road operation.

A portion of the same blend of base stock with TEL (either 1.5 or 3.0 ml/gal.) was blended with two concentrations of each type of sulfur compound ordinarily thought to occur in finished fuel. Concentrations of 0.01 to 0.12% by weight of sulfur, depending on the type were added. Usually two members of each type of sulfur compound were tested.

Research and Motor Method knock ratings were obtained on the samples with added sulfur. They were also rated in cars on the chassis dynamometer, usually immediately after the blends of the same base stock had been rated with various concentrations of TEL without added sulfur. This was in order to mini-

Meet the Authors

Mr. Lovell

Mr. Pulleyblank

Wheeler G. Lovell, associate director of research for Ethyl Corp. Research Laboratories in Detroit, is the author of many technical papers on fuels and engines, and is a member of ACS, API, ASTM, SAE, and the Engineering Society of Detroit. He was graduated from Harvard University and M.I.T., and was associated with General Motors Research Laboratories for more than 20 years. As assistant head of the fuel department for General Motors, he worked on problems of engine and fuel relations, and anti-knock agents and high-compression engines. This included work on molecular structure and knock, as well as on high-output fuels such as triptane.

Donald H. Pulleyblank, engineer in Ethyl's research laboratories, was graduated from the University of Michigan in aeronautical and mechanical engineering. For two years he worked on design and testing of fuel-injection pumps and nozzles—first for B. G. Parsons, a consultant for American Bosch Corp., and later for Ex-Cell-O Corp. For the past 14 years he has been engaged in research on fuels and engines in Ethyl's laboratories.

mize variations in ratings because of changes in engine condition or atmospheric variables. All knock ratings were obtained in terms of primary reference fuels.

The knock ratings obtained in the tests with the groups of fuel blends were used to measure the effect of added sulfur on TEL efficiency. TEL efficiency is defined as the ratio of the volume of TEL required in the low-sulfur (or sulfur-free) fuel to that required in the same fuel with a higher sulfur content for the same anti-knock value. The efficiencies were determined on two bases: one in terms of the TEL susceptibility of the base fuel with its native sulfur and the other in terms of the TEL susceptibility which the base fuel would have were it free of sulfur. This sulfur-free susceptibility was estimated from the sulfur-type analyses and data as shown in Fig. 1, which shows TEL efficiencies for various amounts and types of sulfur compounds.

The absolute (sulfur-free-based) values of efficiency for the commercial fuels are subject to some uncertainty for several reasons, it was reported by the Ethyl Corp. investigators. A significant portion of the sulfur in the base fuel is classified as residual (not extracted by the procedure used in analysis of the other six types), and both the chemical nature of this sulfur and its effect on TEL are unknown; it was considered to be thiophenic in the analysis. There is also some evidence, it was stated, that the effect of various types of sulfur compounds is not strictly additive, as it was assumed to be in the analysis. Also, the effect of the native sulfur in the road tests would be less than in the Motor or Research methods. In contrast to this, it was brought out, the relative ratings or those in terms of the TEL efficiency of the base fuel, are direct measurements involving no assumption, and they are much more reliable.

This general method for reckoning or measuring sulfur effect on leaded fuels is desirable because of its convenience, and because it has a direct meaning; i.e., the ratio of volumes of TEL required in the same fuel with high—and low—sulfur contents for the same anti-knock value. It is convenient to use this ratio because it had been found to be substantially independent of TEL concentration.

In comparing the TEL efficiencies obtained by the different test methods, taking the TEL efficiency of the fuels as received as 100%, averages of TEL efficiencies for 66 fuel blends with added sulfur were found to be 64.0% for Motor and 65.2% for Research method. As computed on a sulfur-free basis, the corresponding

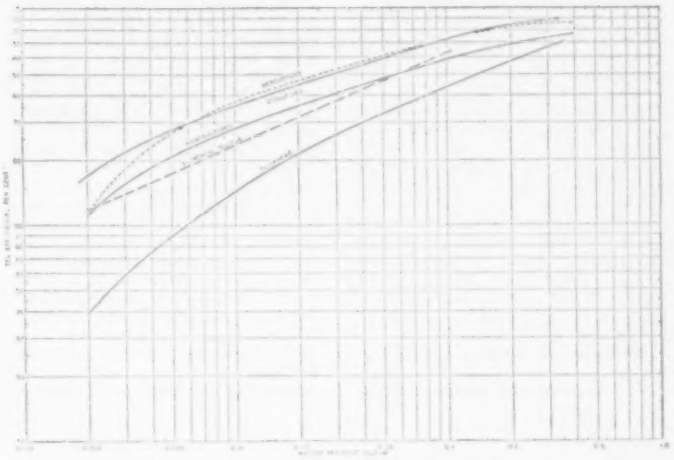


Fig. 1—Effect of sulfur compounds on TEL efficiency in low-sulfur base fuels—composite data, Motor Method ratings, sulfur-free basis.

ratings were 31.4% for Motor and 32.0% for Research. Consequently, it was reported, the average of all the data shows no significant difference in the effect of sulfur compounds on the volume of TEL required, as measured by Motor and Research methods. This does not hold in specific cases, it was reported, where the difference might be so great that results by one method do not permit of a good prediction of results by the other method.

In comparing the results in laboratory knock-test engines with those in automobiles, it was found that, when the gasolines were rated in current model vehicles, the added sulfur compounds had less effect than the laboratory results indicated. Although there were wide variations in the effects of the sulfur compounds dependent upon the vehicle and the base fuel, it was found that the average TEL efficiency on the road was about 82% as against 65% in laboratory engines, when this was evaluated on the basis of 100% TEL efficiency in the base fuel. When this efficiency was evaluated in terms of the estimated TEL susceptibility of the sulfur-free fuel, the road results showed approximately a 40% TEL efficiency, as compared with about 32% efficiency in laboratory engines.

The report discusses as follows the evaluation of TEL efficiency in fuels with added sulfur compounds, in the light of the 82-65 relationship of road and laboratory engines:

"The previously mentioned average values of 82 and 65% TEL efficiency for road and laboratory tests do not give a direct measure of the increase in TEL required to maintain the fuel anti-knock quality in the presence of added sulfur.

"The additional TEL required is:

$$V\left(\frac{1}{E}-1\right)$$

where: E is the efficiency relative to that of the base fuel, and V is the volume of TEL in the base fuel. The expression is obtained from the definitions of the quantities. Inasmuch as the volume of TEL required with high-sulfur fuel is V/E, and with the low-sulfur fuel is V, the difference is the additional TEL and is $(V/E) - V$, or:

$$V\left(\frac{1}{E}-1\right)$$

"The average efficiency values of 82 and 65% for the commercial fuels may be used to estimate the additional volume of TEL required for the average fuel, sulfur content, and sulfur addition used in this test. The values are as shown in the following tabulation:

	Relative TEL Efficiency %	TEL Content of fuel (ml/gal.)	Additional TEL Required to Offset Added Sulfur (Approx. 0.04%)
Laboratory data	65	1.5	0.81
Laboratory data	65	3.0	1.62
Road data	82	1.5	0.33
Road data	82	3.0	0.66

"Therefore, it appears that, on the basis of the use of the fuel on the road, the laboratory data are in error by somewhat more than 100% in the matter of predicting the penalty in TEL requirements caused by allowing the current commercial fuels to contain more sulfur. The additional TEL required according to the automobile ratings is only about 40% of that indicated by the laboratory ratings.

"Conversely, the laboratory data

appear to predict too large a reduction in TEL requirements because of the removal of sulfur from the fuel, according to the criterion of anti-knock value on the road.

"This difference between the effect of sulfur in laboratory engines and on the road would not have been expected because an extreme variety of laboratory test engines and operating conditions have had little or no influence on the sulfur action. In these laboratory engines a wider range of such variables as inlet-air temperature, jacket temperature, spark advance, and fuel-air ratio than exists in any passenger car has been found to have only a slight effect, if any, on the sulfur action.

"However, laboratory knock-test engine-induction systems are different from those of automotive engines, and the conditions of operation are entirely different. The knock-test engine is a single-cylinder engine which has an inlet pipe, and not a manifold; it operates under fixed conditions, and receives the whole fuel carbureted in any appreciable period of time. The automobile engine is multi-cylinder; it has an inlet manifold; and, in either a road test or actual use, it operates under highly transient conditions when maximum fuel anti-knock quality is required. Consequently, some cylinders of the automobile engine receive a fuel considerably different from the whole fuel because of fuel-component separation and maldistribution.

"The effect of the added sulfur can be measured in terms of the octane-number loss instead of in terms of tetraethyl lead efficiency. The data show the following average loss of octane number for all fuels by the various knock-test methods:

	Knock-Test Method or Engine		
	Research	Motor	Car (Average)
Average loss of octane number due to added sulfur	2.04	1.58	0.95

"The effect of sulfur in cars according to this criterion is comparable to the effect in cars on the basis of the additional TEL required; i.e., sulfur is only about half as deleterious in road tests as it is in the laboratory knock-test engine."

References

(1) "Road Effectiveness of Tetraethyl lead as Influenced by Added Sulfur", by Donald H. Pulsyblank and Wheeler G. Lovell, Ethyl Corp. Research Laboratories, Detroit.

The Effects of Sulfur in Motor Gasoline on Engine Performance

The principal portions of a paper of the same title, presented at the 15th Mid-Year meeting of the API Division of Refining, Cleveland, May 4

By *R. E. JEFFREY, J. B. DUCKWORTH and E. J. GAY**

The effects of motor gasoline with sulfur content of 0.25 to 0.30% on engine wear and other characteristics, as compared with fuels of 0.056 to 0.140% sulfur content, were extensively studied as a CRC-sponsored project in field tests involving 7 fleets of 62 vehicles covering wide sections of the country. The resulting test data showed the influence of the high-sulfur fuels may vary widely from a pronounced effect on cylinder and ring wear under certain operating conditions, to no effect under continuous operation at normal engine temperatures. The increased wear in general does not check with field service experience. Valve operation and life, muffler life and exhaust system corrosion in general were not found adversely affected. In most cases there was evidenced little or no effect of high sulfur fuel content on engine varnish and sludge.

THE increasing utilization of high-sulfur crudes, for the purpose of supplementing crude supply during and following World War II, has focused attention on the possible effect of sulfur in motor fuel on engine wear, corrosion, deposits, and other factors affecting engine life.

Extensive work on these problems had not been conducted since the early 1920's largely because, since that time, improvements in engine design—particularly the almost universal use of crankcase ventilation and thermostatic control of engine jacket temperature—have reduced the incidence of trouble from sulfur in motor gasoline to a point where it is not currently recognized as an acute problem. This is further borne out by the satisfactory operational experience on the West Coast of the U. S. where moderately high-sulfur levels in gasoline have been used for many years. Also certain surveys made prior to the war did not tie increased sales of pertinent engine and exhaust-system parts to the area where higher-sulfur fuels were sold.

However, it was recognized that adequate up-to-date technical information was not presently available; and, at a meeting of the Executive Committee of the Coordinating Research Council Board of Directors, the petroleum members proposed that factual data on this subject would be desirable. The problem was assigned to the Motor Fuels Division of the Coordinating Fuel Research Committee, Sept. 17, 1945, and a group on sulfur in motor gasoline was organized to handle the project.

Laboratory Engine Tests

1—Because of the complexity of the overall problem it was decided to conduct relatively inexpensive laboratory dynamometer tests. These tests would serve to indicate the conditions under which sulfur might affect engine performance and, further, would aid in the selection of fuels for field service tests which were to be run at a later date. Dynamometer tests consisted of various single-cylinder and multi-cylinder engine tests, run under a wide variety of test conditions, ranging from high to low operating temperatures and from continuous to cyclic or intermittent operation.

2—Approximately 100 laboratory engine tests, covering at least 3,800 test hours, when compiled and analyzed showed that cylinder-bore and

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E. J. Gay, consultant, Detroit, was coordinator of the field service tests on sulfur in motor gasoline.

piston-ring wear increased with higher sulfur content of the gasoline. The laboratory test panel, recognizing that normal field operating conditions and geographic location might produce results differing from laboratory dynamometer tests, recommended the adoption of a full-scale field service test.

3—The laboratory test panel recommended field service tests using a fuel containing 0.25 to 0.30% sulfur for the higher-sulfur value, and a fuel of less than 0.10% for the lower-sulfur value. This range was chosen so as to bracket commercial-gasoline sulfur contents which would normally be expected to be distributed in this country over the next several years. At present most commercial gasolines are substantially below this higher value. The panel further recommended that the fuel of lower sulfur value used for tests on the West Coast could be 0.15% or less.

Engine Field Service Tests

1—The recommendation of the laboratory tests panel was accepted, and in the summer of 1947 a field test panel was organized to initiate a practical field test program. The CFR-MFD group on sulfur in motor gasoline recognized that any one field service-test program would not furnish a complete and final appraisal of the problem. However, these tests would help sort the problem into definite categories wherein sulfur in gasoline may or may not be a problem, and they would provide guidance for future work.

2—After conferences with many fleet owners in various parts of the country, 7 fleets (62 vehicles) were selected. These fleets represented a wide variety of equipment, from passenger cars to heavy trucks, in services ranging from light-duty city-delivery to over-the-road heavy-duty. The test locations covered a considerable range of ambient air temperatures. A more complete account of each fleet is shown in Table 1.

3—During the early conferences on the conduct of the field test program, representatives of Ford, Chevrolet, and Chrysler agreed to supply new test engines for the fleets using their make of vehicle. They also agreed to undertake the task of measuring these same engines after their removal at the end of the test. The American Petroleum Institute agreed to assume an estimated expense of approximately $50,000 for the direct cost of the test to the Coordinating Research Council, Inc. The oil companies were to furnish project engineers and other personnel for the technical surveillance of the test vehicles.

4—Original plans called for the supply to all fleets of a naturally-occurring high-sulfur gasoline. In selecting the test fleets, it became apparent that locations ranging from central Pennsylvania to the West Coast would necessitate shipping from the West Coast (and storing) approximately 200,000 gal. of gasoline. This presented a difficult problem of supply, as well as an item of very considerable expense. As a result, consideration was given to the work of the laboratory test panel on various sulfur compounds.

This work showed that a number of sulfur compounds, when added to a given fuel, gave approximately the same results from the standpoint of cylinder-bore and piston-ring wear as was obtained with fuels containing an equal amount of natural sulfur. A further check test was made by one of the oil-company research laboratories, using disulfide oil as a means of raising the sulfur content of the test gasoline. This test confirmed the earlier results and, upon the recommendation of the fuels panel, the sulfur group agreed to use disulfide oil as a means of obtaining higher sulfer values in the gasoline.

5—The gasoline normally furnished the fleet was used as the control fuel. To this fuel a sufficient amount of disulfide oil was added to obtain the desired level of 0.25 to 0.30% sulfur. This gave the additional advantage of having the base-stock tetraethyl lead content and octane number (prior to the addition of the disulfide oil) the same for both fuels. There was one exception to this procedure: One West Coast fleet was provided with a naturally-occurring high-sulfur gasoline. This was done to give a direct comparison with another fleet in the Midwest, in similar service, but using gasoline with disulfide oil added. In most fleets extra tankage and another dispensing pump were provided to handle the special fuel.

6—No attempt was made to place special crankcase lubricating oils in these various fleets, because it was felt that variables other than the sulfur content of the gasoline should not be introduced at this time. It

Meet the Authors

Mr. Gay

Mr. Duckworth

Mr. Jeffrey

Errol J. Gay, consulting engineer, Detroit, served as coordinator at the CRC field service tests on sulfur in motor gasoline. During the war he made several trips overseas as consultant for the U. S. War Department and received the award for "Exceptional Civilian Service" as a result of his work. Mr. Gay has been with Ethyl for more than 15 years prior to his engaging in consulting work in 1947. At present he also serves as American technical advisor to the Associated Ethyl Co., Ltd., London, and as technical consultant to Thompson Products Inc., Cleveland.

J. B. Duckworth became associated with Indiana Standard's research department in 1936, after graduation from Purdue University with a B. S. in mechanical engineering. Entering the military service in 1942, he was assigned to the fuels and lubricants branch of the Air Force's materiél Command at Wright Field; and for his service he was awarded the "Legion of Merit." He returned to Indiana Standard's research department as section leader in 1946; and is now assistant director of research, in charge of mechanical research.

R. E. Jeffrey, Jr., automotive group leader of Shell Oil Co.'s products-application department, was graduated by Stanford University with degrees in engineering and mechanical engineering. He joined Shell as research engineer in the motor laboratory at Martinez, Calif., in 1937. His activities were concerned primarily with automotive fuels and lubricants, particularly in the integration of research activity with application experience. During the war he was assigned to the Office of the Chief of Ordnance in connection with the initiation of Ordnance fuels and lubricants program. He organized and directed fuels and lubricants research and development for Ordnance materiél and later for all Army Ground Force equipment. He was awarded the Legion of Merit, and returned to Shell in 1946 to assume his present position.

TABLE 1—Summarized Data on CFR Fleet Tests on Effect of Sulfur in Motor Gasoline

Fleet No. Vehicle Type	Test Location	Number Vehicles on Test	Type of Service	Total Average Test Miles per Vehicle	Sulfur Content Wt.-%	Condition of Engine at Start of Test	Lowest Mean Minimum Temp. (° F.)	Highest Mean Maximum Temp. (° F.)	Average Miles Per Day	Engine Starts Per Day	Idle Periods Per Day	Oil Type and SAE Grade
Fleet 1	Middle Atlantic state		Heavy-duty	L 39860	L 0.114							
Vehicle A		6		H 39855	H 0.256	Rebuilt	16.7	85.3	114	1	1,140	Heavy-duty 30
Fleet 2	Central Midwest		Heavy-duty	L 87670	L 0.091							
Vehicle B		8		H 95536	H 0.281	New	19.3	88.3	240	7	5	Premium 30
Fleet 3	Large Midwest city		Light-duty intermittent	L 11139	L 0.063							
Vehicle C		8		H 10730	H 0.267	New	10.0	88.3	36	80	0	Premium 30 and 40
Fleet 4	Large Midwest city		Light-duty intermittent	L 5443	L 0.066							
Vehicle D		8		H 5987	H 0.267	New	10.0	88.3	15	15	7	Regular 10 and 20
Fleet 5	Large Midwest city		Medium-duty	L 18783	L 0.056							
Vehicle E		4		H 16168	H 0.269	New	10.0	88.3	52	13	58	Regular 30
Vehicle E	Large Midwest city	4	Intermittent	L 23270	L 0.056							
				H 20314	H 0.269	New	10.0	88.3	52	13	58	Heavy-duty 30
Fleet 6	Large West Coast city		Light-duty	L 3134	L 0.140							
Vehicle D		6		H 3450	H 0.290	New	38.8	67.7	10	11	5	Regular 20
Vehicle G	Large West Coast city	6	Intermittent	L 2912	L 0.140							
				H 2908	H 0.290	New	38.8	67.7	10	11	5	Regular 20
Fleet 7	Southwest coast		Medium-duty	L 14304	L 0.132							
Vehicle F		2		H 15276	H 0.264	New or rebuilt	37.9	84.2	52	7	1	Heavy-duty 30
Vehicle H	Southwest coast	2	Light-duty-intermittent	L 6901	L 0.132							
				H 6829	H 0.264	New or rebuilt	37.9	84.2	18	19	2	Heavy-duty 30
Vehicle HA	Southwest coast	2	Medium-duty	L 14965	L 0.132							
				H 16336	H 0.264	New or rebuilt	37.9	84.2	38	8	2	Heavy-duty 30
Vehicle I	Southwest coast	2	Light-duty-intermittent	L 9011	L 0.132							
				H 4579	H 0.264	New or rebuilt	37.9	84.2	13	11	3	Premium 30
Vehicle J	Southwest coast	2	Intermittent	L 9965	L 0.132							
				H 8572	H 0.264	New or rebuilt	37.9	84.2	34	12	1	Premium 30

was also not desirable to risk the psychological problems which might arise, and which could be blamed on the change of oil type. Each fleet operator was asked to agree to continue using the same brand of oil throughout the year's test duration. In one fleet two types of oil were already in use, and in that case the sulfur-test vehicles were split half and half between the two oils: One oil was a regular-grade; the other oil was a heavy-duty grade.

7—As shown in Table 1, new engines were installed in four fleets. In the fifth fleet the trucks were new at the start of the tests, so that these engines could be considered as new engines. The engines from the two remaining fleets were disassembled, rebuilt, and measured before the start of the test. New mufflers were installed on all vehicles. A project engineer from the oil company supplying the fuel was assigned to each test fleet. It was his duty to provide technical surveillance of the test, following procedures set down by the field test panel. No attempt was made to change the operator's methods of running his fleet, as this would then take the test out of the category of a practical field operation. This procedure developed certain disadvantages, which will be discussed later in this paper.

8—Periodic fuel and used-oil samples were checked by the project engineer's parent company. Also, used-oil samples were sent to the Shell laboratories on the West Coast for a reference check of all oils by one laboratory. Just prior to the start of the tests the engine-sludge and varnish group of the Motor Fuels Division suggested that this sulfur field-test program presented an excellent opportunity to obtain comparative data between laboratory and field tests on engine deposits. Accordingly, arrangements were made to send sufficient supplies of gasoline and lubricating oils to several laboratories for FL-2 and L-4 tests.

9—Actual field tests started with some vehicles late in October of 1947. All tests were in operation by February 1948, and were completed by the late spring of 1949. Prior to the end of the tests, two new panels within the sulfur group had been formed. One of these was the engine-inspection panel, and the other was the engine-sludge and varnish-rating panel. Inspection procedures were set up by each panel; and these procedures were, in general, followed for each fleet.

All engines (from four fleets) furnished by Chevrolet, Chrysler, and Ford were removed from the test vehicles, and shipped back to the engineering departments of these companies for inspection and measurements. The engines from the other three fleets were removed and inspected at/or near the fleet location. Engineers from the manufacturers were able to view all engines except one fleet on the West Coast. In most cases at least two men from the engine-inspection panel were able to view all of the test engines.

Through a very fortunate arrangement all fleets, with the exception of one West Coast fleet, had at least one man from the sludge and varnish panel available to help start the rating of the engines. All the engines which were sent back to Detroit for inspection and measurements were thoroughly rated for sludge and varnish by the same two men in order to establish uniformity in standards of rating.

Engines which came back to the manufacturer were measured and rated in accordance with standards of accuracy normally used by the manufacturer. Likewise, engines examined in the field were carefully measured by skilled personnel. In order to achieve more complete coordination of data, the project engineer from each of the fleets using Chrysler, Ford, and Chevrolet engines were present at the respective manufacturer's plant during the time the engines were being inspected and measured.

10—The National Research Laboratories of Canada cooperated with the Coordinating Research Council, Inc., on this problem; and, during 1946-48, carried out a service test at the Canadian Army Proving Grounds, using military vehicles. Operation under stop-and-go driving conditions produced no significant difference between fuels containing approximately 0.05 and 0.30% sulfur. The cylinder-bore wear observed in the Canadian tests, however, did not exceed 0.001 in. after 2,300 miles operation on either low- or high-sulfur gasoline.

11—After the inspections had been completed, the entire file of data on the seven test fleets—representing many hundreds of pages of observations—was turned over to a seven-man analysis panel. This panel was charged with the responsibility of preparing the final report on the tests for the CFR committee. It was the duty of this panel to sift out the essential information, and to present this information in report form. The report was prepared, and has been

approved, by the Coordinating Fuel and Equipment Research Committee. It is now available from the American Petroleum Institute and the Society of Automotive Engineers, under the title "Sulfur in Motor Gasoline, January 1950."

Results

1—Sixty-two vehicles completed field service tests at seven test sites during the period October 1947 to June 1949. Two motor-gasoline sulfur levels of 0.056 to 0.140% and 0.25 to 0.30% were compared in regard to engine wear and cleanliness. A total of 1,501,698 test miles was accumulated in service, ranging from light-duty to intermittent-duty to continuous heavy-duty. From these tests the following results may be of major interest:

a—Twenty vehicles in three fleets—representing four types of engines used in a heavy-duty or moderate-duty continuous service, such as over-the-road trucks, urban bus service, or medium bus service—showed essentially no difference in wear for gasoline sulfur content within the limits prescribed by the test procedure and as shown in Table 2A. No inter-city bus-service test was conducted; but, based on the results of the over-the-road truck service, it may be reasonable to assume that the same result would apply.

b—Thirty-four vehicles in four fleets—representing five types of engines, in light-duty intermittent service, with many stops and starts or idle periods per day—produced consistent differences in wear within the sulfur limits prescribed by the test procedure and as shown in Table 2B. Typical services for these vehicles are city delivery routes such as bread and parcel delivery, light repair or trouble shooter trucks for gas, telephone and electric utilities, supervisor's cars, etc.

c—Eight vehicles in one fleet—engaged in typical medium-duty intermittent-delivery service, door-to-door—showed a marked increase in wear. In this fleet, wherein the low-sulfur fuel was 0.056% and the high-sulfur fuel 0.269%, and wherein a regular-grade oil was used, wear for the high-sulfur engines had progressed to the level of requiring an overhaul (see Table 2C).

The use of a heavy-duty crankcase oil (REO-37) in this fleet produced a 50% reduction in cylinder wear in vehicles operated on the low-sulfur fuel, but did not appreciably reduce cylinder wear in the high-sulfur vehicles. Cylinder wear for both oils and the *high-sulfur fuel* was 0.005 to 0.006 in. However, wear, when using the (REO-29) regular oil and the *low-sulfur fuel*, was 0.003 in. With the *low-sulfur fuel* and the (REO-37) heavy-duty oil, the wear was about 0.0015 in., or approximately one-half the amount of wear obtained with the regular oil.

d—In the same fleet (No. 5), wherein a heavy-duty oil (REO-37) was compared with a regular oil (REO-29), it was noted that crankcase deposits and oil ring-groove deposits were reduced for both high- and low-sulfur vehicles by the heavy-duty oil.

e—In a comparison of one fleet (West Coast), using a naturally-occurring high-sulfur gasoline against one other fleet (a Midwest city) using the same vehicles in the same type of service and using a gasoline with disulfide oil added, wear results were substantially equivalent. This confirms previous tests made during the laboratory test phase.

f—Valve operation and valve life were not adversely affected by high-sulfur fuel. Three low-sulfur vehicles in one heavy-duty fleet were overhauled during the test period because of sticking valves.

g—Muffler life and exhaust-system corrosion were not adversely affected by high-sulfur fuel.

h—In all but one of the seven fleets there was little or no effect of high sulfur on engine varnish and sludge deposits. This other fleet showed differences of 7 to 10 points (out of a possible 100) in favor of the low-sulfur fuel.

i—Laboratory dynamometer FL-2 tests qualitatively reflect the effects of high sulfur on cylinder and ring wear in light-duty intermittent service, but L-4 tests do not reflect wear in medium- to heavy-duty service.

j—Based on two fleets in light-duty-intermittent service, and within the range of atmospheric conditions and temperatures prevailing during the test period (the actual mean minimum air temperatures were 18° and 45° F.), there was no apparent influence of ambient air temperatures or geographic location on differences in engine wear between high- and low-sulfur fuels.

k—The test data do not permit separation of the effect of engine design on the difference in wear due to sulfur because of the influence of type of service or duty. In one fleet, where two types of vehicles were employed, the percentages of increase in wear with high-sulfur fuel were not significantly different. However, the absolute rate of wear in one type of vehicle was aproximately twice as high as that in the other with both high- and low-sulfur fuels. The maximum difference in bore wear was 0.0016 in., and the test mileage was 2,900 to 3,400.

Summation

1—The test data reported show that the influence of up to 0.3% sulfur in gasoline, as compared to gasolines of 0.1% sulfur and lower, may vary from a pronounced effect on cylinder and ring wear, under some operating conditions, to no effect under continuous operation at normal engine temperature. This increased wear, to a considerable extent, does not check general field-service experience, even in the areas where high-sulfur gasolines have been widely used.

2—It is the opinion of the authors of this paper that there is ample material for study in the CRC report on sulfur in motor gasoline. The engine manufacturer and petroleum refiner may wish to do further work with their own products—using their own test facilities, following the several avenues of investigation which are open to both. This is as it should be, inasmuch as the problem is not theirs to establish competitive and economic boundaries.

TABLE 2—Summary of Engine-Cylinder and Ring Wear

Fleet	Vehicle Type	Test Fuels Wt.-% Sulfur		Cylinder-Bore Wear at Top Ring Corrected for Mileage* (Inches)		Top-Ring Wear Corrected for Mileage* (Inches)		Increase in Wear of High-Sulfur Over Low-Sulfur Corrected for Mileage† (Per Cent)	
		Low-Sulfur	High-Sulfur	Low-Sulfur	High-Sulfur	Low-Sulfur	High-Sulfur	Bore	Rings
A—HEAVY-DUTY OR MODERATE DUTY CONTINUOUS SERVICE									
1	A	0.114	0.256	0.0044	0.0038	0.0044	0.0050	—14	14
2	B	0.091	0.281	0.00168	0.00137	0.0097	0.00963	—18	—2
7	F	0.132	0.264	0.0040	0.0044	0.0192	0.0203	10	6
7	HA	0.132	0.264	0.0090	0.0051	0.0278	0.0299	—43	7
7	J	0.132	0.264	0.0023	0.0023	0.021	0.027	0	29
B—LIGHT-DUTY INTERMITTENT SERVICE									
3	C	0.863	0.267	0.0020	0.0042	0.0292	0.0490	110	68
4	D	0.066	0.267	0.00165	0.00296	0.0093	0.0190	80	105
6	D	0.140	0.290	0.0032	0.0056	0.0201	0.0313	75	56
6	G	0.140	0.290	0.0065	0.0122	0.0614	0.0804	88	31
7	H	0.132	0.264	0.0107	0.0177	0.0478	0.0688	65	44
7	I	0.132	0.264	0.0054	0.0120	0.0411	0.0786	123	92
C—MEDIUM-DUTY INTERMITTENT-DELIVERY SERVICE									
5 Regular oil	E	0.056	0.269	0.0030	0.0065	0.0126	0.0239	117	90
5 Heavy-duty oil	E	0.056	0.269	0.0013	0.0052	0.0082	0.0173	300	111

* Average actual wear divided by average actual miles and multiplied by 10,000 to give 10,000-mile units.

† Per cent change $= \frac{\text{wear high-sulfur (per unit mile)} - \text{wear low-sulfur (per unit mile)}}{\text{wear low-sulfur (per unit mile)}}$

Use of Bacteria Studied as Measure Of Stream Pollution by Wastes

Condensed from a paper titled "Use of Bacteria as Test Organisms in Stream-Pollution Studies," presented at the 15th Mid-Year Meeting of the API Division of Refining, Cleveland, May 3

From a Report by W. B. HART, Atlantic Refining Co.

THE value of biological surveys of streams as adjuncts to industrial waste disposal programs is being widely recognized, the report by W. B. Hart brought out. "The biological survey procedure is being used by several large corporations," he said, "for the purpose of establishing a record of the stream condition before and after waste-treatment operation. Not only does it show the condition of the stream as it exists at the time of the survey, but it also gives definite indications of past history and, of course, an actual record of stream-recovery progress."

In his talk Mr. Hart presented a summary of the API research project recently completed at Pennsylvania State College for the purpose of determining what forms of bacteria could be used as test organisms in measuring stream pollution and how such tests should be conducted.[1] The results of this survey were not positive, he stated, in that the predominating forms of bacteria were about as pronounced in number in polluted as in clean water. No single form was sufficiently significant as to its characteristics to be regarded as a good test organism.

However, said Mr. Hart, the investigation did serve to further establish the value of stream surveys as defense mechanism for industry in waste disposal work. Its findings will be of value in studies of other biological forms as test organisms for measuring stream pollution. "Many valuable features were brought out for proceeding with other forms", said Mr. Hart, "such as various invertebrates which are also being studied as test organisms under a grant from the API, as well as fish and various invertebrate forms which will be reported on at some later date."

Mr. Hart also reported briefly on the biological survey of the Conestoga Creek Drainage Basin, Lancaster County, Pa., as a proposed measure of stream conditions. This survey was carried out by the Academy of Natural Sciences of Philadelphia, and a report on the work is available.[2]

The general use of biological stream surveys as a part of waste disposal programs was discussed as follows by Mr. Hart in his talk:

"When a stream to a reasonable degree supports aquatic life of various kinds, the state may be assured that that stream is in a clean and healthy condition. This perhaps may not be a condition of pristine purity but, on the other hand, it certainly will not be an unclean or unhealthy one. Here, again, these organisms become the measurement of the extent to which the pollution exists, i.e., a measurement which can be used by state agencies with much simplicity and confidence.

"Industry can use these organisms to advantage by establishing through tests, in which the organisms are subjected to the wastes to be discharged, what wastes can be discharged without treatment and, at the same time, without harm to the stream. Conversely, such tests will determine what wastes definitely require treatment prior to discharge. Thus the quantity of wastes which requires treatment can be reduced to the absolute minimum, and thereby the capital costs of treatment plants—and their operating costs as well—can be held down. All these claims are based upon experience.

"In its overall makeup, a stream presents a wide variety of living organisms; and one of the questions which confronts anyone who wishes to follow the procedures recommended previously herein concerns what organisms should be used. Naturally, the fish in the stream are the most spectacular, as well as the most familiar to the popular mind. Consequently, fish should be one of the forms used in tests to evaluate the toxicity of the waste.

"However, fish must have food; for, without food, they will disappear from the stream just as if they had been destroyed by pollution. Consequently, various invertebrate forms and diatoms—which are minute plants, and which frequently are called the pasture of natural waters—must also be used. Of equal importance are the bacteria which form the first line of attack on various forms of organic pollution and, to some extent, of inorganic pollution.

"In general, it may be said that, if the bacteria and their protozoan-control forms are present in a stream in the proper proportion, other organisms, such as fish and large plant forms, will be there also whether desired or not.

API Research

"Realizing the importance of the bacteria, and the damage which might be done to a stream if these forms were destroyed by industrial wastes, the API, about three years ago, sponsored a research to be conducted at Pennsylvania State College, for the purpose of determining what forms of bacteria can be used as test organisms (and it should be

Meet the Author

Mr. Hart

Dr. Wilson B. Hart, superintendent of services for Atlantic Refining Co., for many years has been active in API committee work on the disposal of refinery wastes. He was graduated by Medico-Chirurgical College as a doctor of pharmacology in 1913, and began his career at Atlantic in 1923 in the chemical engineering laboratory of the company's Philadelphia refinery in 1923. He rose successively through various positions from acid-plant supervisor; assistant superintendent of gas, acid and drainage department; then superintendent of the latter department—until 1948, when he was appointed to his present position.

remembered that bacteria belong to the plant kingdom) and how such tests should be conducted. Practically all of this investigation was carried out under the capable direction of Dr. Robert W. Stone.

"The investigation was financed by a grant of approximately $6000 from the API. Water samples were collected from 171 sources in Pennsylvania—11 being from unpolluted waters, 42 from mildly polluted streams, and 118 from moderately to heavily polluted streams. Each water sample collected was checked for total bacterial count, types of bacteria present, the presence of coliform bacteria, and coliform count.

"Representative bacteria were selected from each sample, and were classified as to genus by standard morphological and physiological tests. Physical and chemical tests of the water were conducted at the time of the collection of some of the samples for correlation with some of the bacteriological results. These included tests for temperature, dissolved oxygen, pH, alkalinity, and conductivity.

"The investigation of these samples involved 1402 cultures which were broken down as to findings into 7 types of water, ranging from mild pollution in both soft and hard waters, through heavy pollution of similar hard and soft waters. The bacteria found were predominantly gram-negative rods, and from 80 to 90% were found to be members of *Achromobacter*, *Flavobacterium*, *Alcaligenes*, and *Pseudomonas*. Other genera found were *Micrococcus*, *Sarcina*, *Chromobacterium*, *Serratia*, *Streptomyces*, gram-positive rods, and yeasts.

"Both *Aerobacter* and *Escherichia* are included under coliform types.

"The surprising part of the whole investigation was that these forms were just about as pronounced in number in the polluted water as in the clean water. There were about the same variety of types in each kind of water, and no single form was sufficiently significant as to its characteristics to be regarded as a good test organism."

References

(1) "Report on Toxicity of Industrial Wastes", Pennsylvania State College, Bacteriology Dept., Aug. 30, 1949.
(2) "A Proposed Biological Measure of Stream Conditions Based on a Survey of the Conestoga Basin, Lancaster County, Pa.," Academy of Natural Sciences of Philadelphia.

Operation of Oil-Water Separator

This paper was presented under the title "Operation of API Oil-Water Separator at Trenton Refinery," at the 15th Mid-Year Meeting of the API Division of Refining, Cleveland, May 3

By C. F. MILLER
Socony-Vacuum Oil Co. Inc., Trenton, Mich.

A coalescer has proved an important auxiliary to the operation of a conventional new API-type oil-water separator in a 28,000 b/d refinery including, among other units, a Houdry combination crude and cracking unit and Kellogg delayed-coking unit. Minute particles of oil are coalesced into sufficient size that separation is possible. Excess waste water over the API separator capacity is pumped to a storm pit, and returns by gravity during low rates of flow through the separator. Emulsions are consolidated with slop oils to avoid being introduced into the sewers. An educational program carried on among plant employes has greatly improved the operation of the oil-water disposal system.

IN accordance with the national trend to prevent any possible pollution from refinery wastes and also in order to conserve potential losses, a decision was reached in 1946 to install an API separator and its related equipment at the Trenton, Mich., refinery of Socony-Vacuum Oil Co. Inc.

At that time two large baffled chambers were used as separators to remove the oil in the refinery effluent. These chambers were effecting a fair removal of oil, but they did not have sufficient capacity to process the maximum influent flows experienced during storms.

The present separator system, in addition to the API-designed separator, is composed of a sewer sump equipped with a sediment scraper and an oil skimmer, a coalescer designed to pretreat the water entering the API separator, hay filters to secure further clarification of separator effluent, and a storm pit for storage of excess storm waters

By recent state legislation, the powers of the Michigan Stream Control Commission have been strengthened so as to enforce control of stream pollution. Since this refinery was put onstream in July 1929, the Commission has assisted the refinery in the problem of stream pollution. To date the refinery effluent has met its approval.

The refinery has a capacity of 28,000 bbls. of crude. It consists of a Houdry combination crude and cracking unit, Polyform unit, Kellogg delayed-coking unit, pipe-still unit, solutizer and doctor-treating plants, boiler house, and grease and compounding plant. The refinery and tank farm are situated on 160 acres. All process water and surface drainage flow through the separator.

Design

The oil-water separator consists of 6 distinct parts: 1, preliminary sump; 2, coalescer; 3, API separator; 4, oil-recovery system; 5, storm pit; and, 6, sludge pit (see Fig. 1).

In general, the design of the preliminary sump was patterned after an API oil-water separator. The sump consists of an inlet distribution section, a sludge-removal section with scrapers, an oil-separation section, and a discharge-sump section. Overall dimensions of the sump are 40 ft. long, 25 ft. wide, and 22 ft. deep. However, the depth of the water in the oil-separation section is only 4 ft. The sump was built 22 ft. deep because of the insufficient slope of the land upon which the refinery is located. A large steam reciprocating pump (14 x 14 x 16) transfers the water to the coalescer. This type of pump was used so the water and oil would not be emulsified in the pumping operation.

A coalescer was constructed, and it was put in service during May 1949. This coalescer is an earth

revetment-type pit with an inlet spider on the bottom, filled with stone and sand and has an outlet line at the top. The coalescer bed is composed of 12 in. of 2-in. stone, 6 in. of 1-in. stone, and 2 ft. of sharp sand (Fig. 2). The capacity of the coalescer is 2,700 gpm based on 2 gpm/sq. ft. of effective coalescer cross-section area.

The design of the separator follows very closely the features as outlined in the API publication "Disposal of Refinery Wastes", Sect. 1, "Waste Water Containing Oil" 3d Edition. Overall dimensions of the primary stage are 60 ft. long, 18 ft. wide, and 12 ft. deep. Overall dimensions of the secondary stage are 67 ft. long, 18 ft. wide, and 14 ft. deep. The water depth in both stages is 7 ft. The primary-stage settling basin is 43 ft. long, and the secondary-stage settling basin is 55 ft. long. Design conditions include: water flow, 2,500 gpm; gravity of separated oil, 30° API; temperature, 70° F.

The oil-recovery system is of local design; and consists of a 735-sq.-ft. heat exchanger, a 3,000-bbl. insulated tank with 352 sq. ft. of heating coils, and a 500-bbl. storage tank.

Operation

The preliminary sump, in addition to receiving the sewer effluent, also accomplishes a preliminary oil and sludge separation. The sludge which settles to the bottom of the sludge-removal section is scraped by a flight scraper into two small sumps at one side of the preliminary sump. A reciprocating pump (9 x 7 x 10) takes suction from the 2 small sumps, and discharges into the sludge pit. Oil is skimmed periodically from the surface of the oil-separation section through a slotted pipe and pumped to the oil-recovery system.

Water which flows into the discharge-sump section is pumped, by large reciprocating pumps, into the bottom of the coalescer. The pumps (14 x 14 x 16) are low piston-speed pumps, and do not cause emulsion formation because of excessive agitation. The water level in the discharge sump is controlled by the use of an air-purge liquid-level control system for open vessels. The liquid control operates a valve in the steam line to the pumps.

Normally, the water flow averages 600 to 700 gpm, exclusive of rain. During unit shutdowns the flow may reach a peak of 1,000 to 1,500 gpm; and during storms the flow may reach as high as 6,000 to 7,000 gpm. Excess water over that which may be pumped through the API separator is pumped by 2 large vertical-type storm pumps (total capacity, 8,600 gpm) to a storm pit (5,280,000-gal. capacity). The capacity of the API separator is 2,500 gpm, so that a total load of 11,100 gpm may be handled. To date this quantity has not been encountered. Water in the storm pit is returned, by gravity, to the inlet of the preliminary sump during low rates of flow through the separator.

Water enters the coalescer through a distribution spider on the bottom of the pit, and flows upward through the stone and sand bed. The coalescer serves 2 purposes: 1, the rupture of globs; and, 2, the coalescing of minute particles of oil into oil particles of sufficient size so that separation is possible. The water and separated oil flow through the outlet pipe located at the top of the pit. Tests indicate that there is a decided improvement in susceptibility to separation after the water has flowed through the coalescer. No difficulties have been experienced because of plugging or channeling in the coalescer bed, and the bed appears to be self-cleaning. The bed will be replaced at the end of a year's operation, for experimental purposes only, in order to determine the condition of the sand. The coalescer has made a definite reduction in the turbidity of the separator effluent.

Water from the coalescer flows by gravity into the API separator, entering an inlet box through four 12-in. baffled pipes. Oil is skimmed from this section through a slotted-pipe skimmer. Water then flows through ten 10-in. pipes into the distribution box. Overflow from the distribution box passes downward through baskets of 2½-in. stacked raschig rings. No difficulties have been experienced because of plugging of the rings. Inasmuch as a coalescer is used to pretreat the water to the API separator, raschig rings are probably only of minor value in securing coalescence; but there is reason to believe that the rings improve flow distribution in the settling chamber.

The water then enters the settling chamber of the primary stage of the API separator, which is equipped with a flight scraper for sludge removal, and for forcing separated oil into the oil-skimmer pipe and into an oil-retention baffle. Oil is skimmed about four times a day, and sludge is pumped three times a day. Very little sludge is removed by each pumping.

Water then flows over a weir into the inlet box of the secondary stage, through a distribution box into the settling chamber, which is equipped and operated the same as the basin in the primary stage. The effluent flows into the outlet chamber, which contains two hay filters. The hay filters are changed once or twice a week, and the primary value of hay filters is in improving the visual characteristics of the effluent.

Normal operation of the oil-recovery system is to pump skimmed oil and emulsion through the heat exchanger into the settling tank. Exhaust steam heats the oil and emulsion in the heat exchanger to a temperature of 160 to 190° F., depending on the rate of oil flow and the amount of exhaust steam available. The temperature of the oil and emulsion in the settling tank is maintained at 180 to 200° F., using exhaust steam. A clean break is obtained and, periodically, clear water is withdrawn through a drain in the bottom of the tank. Oil which rises to the top of the tank overflows into the recovered-oil tank during the time when oil is skimmed from the separators. When the recovered-oil tank is full, the oil is pumped to the refinery slop tank for reprocessing.

Water and sediment of the recovered oil varies from a trace to

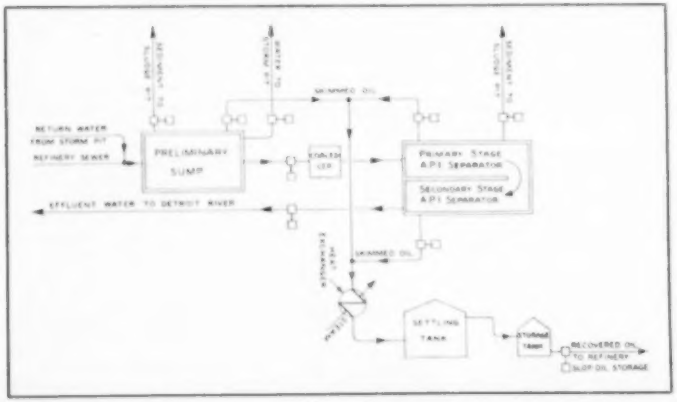


Fig. 1—Simplified flow diagram of the Trenton refinery oil-water separator

5%, and averages 1.5%. The amount of oil recovered averages 50 bbl. to 70 bbl./day. Occasionally a layer of coke-stabilized emulsion forms in the settling tank, which will not break even though the emulsion is heated to 210 to 212° F. Tests indicate that this emulsion will not break with the use of chemical-emulsion breakers. With existing facilities, the emulsion cannot be introduced into an electrolytic crude-desalting unit; therefore, it is withdrawn from the tank, and pumped to the sludge pit.

Consolidation of slop oils and emulsions has proved of benefit to the operation of the separator. By the collection of all slop and emulsion in one tank, it was found that the more troublesome oils and emulsions were not being introduced to the sewers. Inasmuch as one man operates the slop-collection tank, better control is obtained. The oil is pumped into the oil-recovery system for treatment and breaking of emulsions. Crude tank bottoms have also been disposed of in a similar manner.

Sludge removed from the separators is pumped to a 300,000-gal. sludge pit. Solids (clay, silt, and coke) settle to the bottom of the pit, and water is drawn through a swing line into the adjacent storm pit, to be returned to the preliminary sump as flow conditions permit. When the sludge pit was full, a clam-shell crane was used to load the sludge into dump trucks. The sludge was then dumped into an area to be filled with waste dirt.

It should be noted that this process is not a permanent solution for disposal of sludges, as the sludge still contains sufficient quantities of oil and water to prevent indiscriminate dumping. Laboratory tests indicate that it is very difficult, even impossible, to break the emulsion and obtain a solid satisfactory for disposal. However, tests have indicated that the sludge may be broken by the use of a precoat filter if it is treated as it is removed from the separator.

It has been necessary to shut the entire separator down about once every six months for cleanout and in order to make any necessary repairs. Soil conditions at the Trenton refinery cause a large amount of fine yellow clay to be washed into the sewers during storms. A portion of the coke produced in the Kellogg delayed-coke unit is very fine; and, of the part which is unavoidably washed into the sewers, 60% will pass a 200-mesh screen. Over a period of time silt and coke settle in those sections of the separator which are not provided with flight scrapers or other means of sludge removal. Repairs to equipment have all been minor.

Factors Affecting Operation

In all probability the type of oil in the influent is the most important factor in the removal of oil by gravity-type separators. No difficulty is experienced in separating light oils; because the greater the difference in gravity between the oil and water, the greater is the ease of separation. Emulsions of the oil-in-water type (milk emulsions) will not separate, because the gravity of the emulsion is essentially that of water. Emulsions of the water-in-oil type vary in characteristics—some being very light, and others approaching the density of water. This variance is due to the amount and type of oil in the emulsion, and to the conditions under which the emulsion is formed. Heavy oils have been encountered in the refinery ranging in gravity from 3 to 22° API, and some emulsions have gravities as low as 1 to 2° API.

There are two main sources of sludge: clay silt, and coke. The silt and coke absorb oil in the sewers, and in some cases the individual particle has an apparent density approximating that of water, and, therefore, will not settle out in the separator. Also, fine solids tend to stabilize emulsions.

Certain chemical solutions, such as concentrated caustic, will stabilize emulsions. Untreated sewage will carry oil through a separator, whereas treated sewage will not. However, at this refinery such solutions are not discharged into the separator system.

Educational Program

An educational program was conducted in conjunction with the Refinery Conservation Committee to reduce the amount of oil and water which enters the separator. At one time this program reduced the normal water flow from 1,300 to 800 gpm, and recovered oil from 110 to 80 bbl./day. A study was made of the sources of oil entering the sewers, and the appropriate operators were given training in the proper operation of equipment to reduce the amount of oil entering the sewers.

At the Kellogg coke unit, during the drum-switching and watering-down period, a large quantity of emulsion was formed due to the quenching of drum vapors with water in a blowdown stack. Water, oil, and emulsion were collected in a blowdown pit and, due to the size of the pit, it was necessary to draw off water each day. The water drawn off was a "milk" water emulsion and, therefore, could not be handled efficiently in the separator. A system was devised whereby blowdown-pit water is recycled to quench the vapors, thereby reducing the amount of "milk" water which enters the separator.

Higher retaining walls around the coke drums were built in order to confine the coke and water in a small area, so that coke fines would not be washed into nearby sewers. Also, a special sewer and sump were installed at the Hydrobin area in order to prevent the coke and water spillage from entering the refinery sewer system. Coke-cutting crews were given additional instruction in the operation of the coke-cutting hydraulic system, so that water would not be dumped into the sewers at various times during the cutting operation.

Conclusion

Since the API separator was installed in 1946, the quality of the effluent has been improved. In a survey made in 1949, the Michigan Stream Control Commission gave the rating of control as "adequate" for the refinery effluent. However, after thorough studies of the present separator and of the factors affecting separation of oil and waste water, we feel that further improvement in the separator effluent can be made. This can be achieved by improving the quality of the influent to the separator. Therefore, plans are being made to install auxiliary separators at the units in order to remove those oils which are difficult to separate.

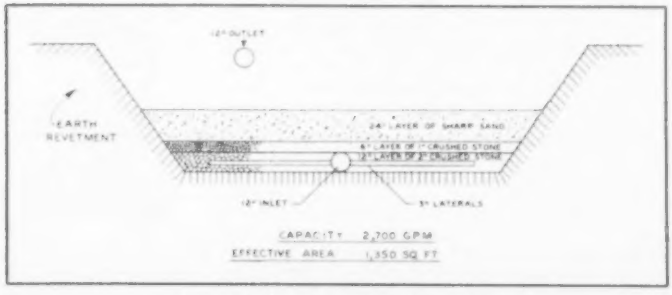


Fig. 2—Sectional elevation of coalescer

PROCESS RESEARCH ENGINEERING

Its Scope, Purpose and Procedure

By JOEL H. HIRSCH, Gulf Research & Development Co.

Process research engineering is a specialized auxiliary to research management, its major activities being the correlation of engineering and pilot plant data, and the economic evaluation of new processes. Its functions properly carried out provide for the more accurate projection of pilot plant data into commercially operating units, for a sounder selection of ideas for development and routing of the research procedure.

IN recent years Gulf Research & Development Co., in common with several other research organizations, has established what is known in our laboratory as the Process Research Engineering Section. Since this is a relatively new field, questions frequently arise, such as: What is process research engineering? What does it do, and what useful purpose does it serve? How does it differ from ordinary process engineering?

First, what is it? Process research engineering comprises the mathematical and engineering treatment of process research, including the correlation of engineering and pilot plant data and the economic evaluation of the processes. The groups handling this work in other research organizations may bear different titles such as "process design", "development" or "process evaluation"; but we believe that the name "process research engineering" is an apt one and that it denotes a specialized field of engineering which promises to become increasingly important.

The expenditures for industrial research in the U. S. amounted to 450[1] million dollars in 1947, and research budgets have increased nearly fourfold since 1930. As research people, we think it goes without saying that these expenditures have been amply justified by results. Nevertheless there is a growing awareness of the need to make every research dollar count. It is the purpose of this paper to show how process research engineering helps to do this. While probably no two research organizations do this work in exactly the same manner, it can be said with assurance that they all have the same objective of maximizing results per dollar expended.

In our laboratory, process research engineering is divided into two major activities, the correlation of pilot plant data and the economic evaluation of new process ideas and research. Let us consider the first activity, the development of engineering tools for process design through data correlation.

Over the past 20 years there has been a marked increase in the utilization of small laboratory pilot units as an aid in the design and operation of commercial equipment in the petroleum refining and chemical industries. Helpful as these new tools have proved, they have nevertheless posed almost as many problems as they have solved. Since results from these units are frequently expanded as much as 10,000 fold, it goes without saying that smooth operation, close material balances, careful analytical work, and accurate measurement and control of process variables are indispensable. But over and beyond these, the interpretation of data frequently presents problems of even greater difficulty—the problems of knowing what to ask for from the pilot plant, and what to do with the results when they have been obtained.

The projection of pilot plant data into commercial design and operation is usually complicated by unavoidable physical differences between the pilot plant and the commercial unit. The most effective means of making this transition is through mathematical correlation of the fundamental variables underlying the pilot plant data. From these relationships it is then possible to calculate results for a wide range of conditions. If the correlation is sound it should be possible to calculate the results to be expected from a commercial unit with equal or greater accuracy than the commercial data. These calculations can then be checked against data from commercial test runs, the test run providing the final proof of the correlation.

Data from commercial units can seldom be used to develop correlations because the commercial unit is rarely operated over a wide range of conditions. On the other hand, it is possible to operate the pilot plant over a wide range of conditions, correlate these data, test their accuracy at one or more points by commercial test runs and then use the correlation with reasonable assurance to predict what will happen at other

Meet the Author

Joel H. Hirsch since 1944 has been head of the process research engineering section, chemistry division, Gulf Research and Development Co., Pittsburgh. He was graduated in 1930 in chemical engineering by the State University of Iowa, and secured his M. S. from Massachusetts Institute of Technology in 1932.

Mr. Hirsch was with Luis de Florez, New York consulting chemical engineer, from 1932 to 1940, engaged in plant scale test work, correlation of chemical engineering data and process design of de Florez cracking units and vertical heaters. From 1941 to 1944 he was with Foster Wheeler Corp., engaged in process design of thermal and catalytic cracking units, and technical supervision of development work and pilot plant activities.

Presented before Annual Meeting, American Society of Chemical Engineers, Pittsburgh, Dec. 4-7, 1949.

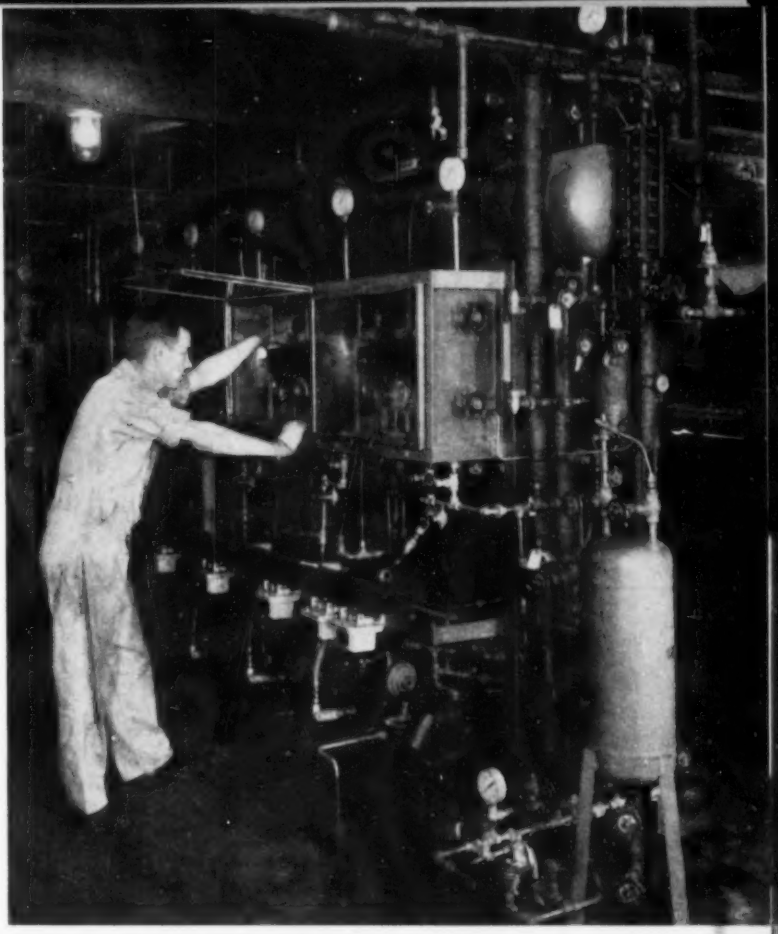
operating conditions on the commercial unit or in the design of new units.

Perhaps an example will be helpful. An article[2] appearing in *Industrial and Engineering Chemistry* for September, 1946, presented what we believe to be a good example of the interrelation between pilot plant work and commercial operations.

This article dealt with design of tubular heaters for thermal cracking. The conditions under which conversion takes place in commercial reaction coils are quite different from those in the laboratory. Mass velocities in laboratory units are usually so low that pressure drop is negligible; these operations are, therefore, conducted at constant pressure and can, if desired, be conducted at substantially constant temperature. Thus fluid density and time of reaction are in relatively simple relation to the extent of conversion. In commercial cracking coils, on the other hand, pressure drop is frequently a dominant factor, and serious errors may result unless it is properly considered in heater design.

In the example mentioned the underlying data were all obtained on small scale pilot plants. These were then correlated on as nearly a fundamental basis as possible and a procedure developed which could be used for calculating the results of commercial operation. The final proof of the reliability of this procedure was obtained from a number of commercial test runs, which it was found could be checked surprisingly well. The test runs alone could not have been used to establish any relationships. Each one covered only a narrow range of operating conditions, and they were entirely dissimilar in charge stock qualities, heating coil design and operating conditions. However, collectively they covered the entire framework of the calculation procedure developed from the pilot plant data, and were indispensable in determining the reliability of that procedure. Thus it is seen that data correlation provides an invaluable link between the pilot plant on the one hand and the commercial unit on the other.

It might be well to add that in making correlations we always try to base them on as much sound theory as possible. In some cases the problem can be solved almost entirely from theory with the pilot plant data providing the check. In most instances a theoretical background can be employed with some of the constants being obtained from empirical correlations. And in some cases the correlation has to be wholly empirical, representing the best expression of the experimental data we can achieve at the moment, but we always strive for some kind of correlation however incomplete. A correlation is never final because correlations are not static things. Like the processes they seek to evaluate and the pilot plants which they seek to interpret they are subject to constant extension and revision as new problems arise and new data become available. We have learned that you don't just make a correlation and then rest on your laurels. It is a continuing service. Having made a correlation you have to keep it up-to-date and reliable, if you expect it to remain in use.



A typical pilot plant solvent extraction unit at the Harmarville, Penna., laboratories of Gulf Research & Development Co.

Over the past three years, we have made detailed correlations on naphtha and gas oil polyforming, fluid catalyst cracking, fluidized catalyst flow, and deep flashing of residua in vacuum pipe stills, to mention a few.

Once a suitable correlation is available a process engineer can make a design or an economic study without waiting for results from a specific set of runs on the pilot plant. He can proceed with the design which may be checked subsequently with one or two pilot plant runs if it is decided to go ahead with the project. The correlations such as we have made of polyforming and catalytic cracking are primarily intended for the purpose of interpolation, thus leaving the pilot plant equipment and personnel free to operate in the broad field of extrapolation.

It is the function of the pilot plant to investigate new stocks or operating conditions outside the range of past work. However, if, for example, data were already available on polyforming Eastern Venezuela naphtha with 20, 40 and 60% outside gas, each containing 30, 50 and 70% olefins, it is the function of the correlation to enable the design engineer to calculate the results at intermediate values such as with 47% outside gas containing 56% olefins.

When properly prepared, correlations will give all of the pertinent pilot plant results with an accuracy at least equal to, and generally somewhat better than, that with which they could be obtained from a limited number of runs on the pilot plant; since the correlation tends to average a large number of runs. Obviously, it costs much less to make

a correlation of past data than it does to make additional runs on the pilot plant, so a correlation saves both time and money.

Let us now consider the second major activity of process research engineering, the economic evaluation of new process ideas and research. In this activity it is our job to look at each new idea and research project with the question: Even if this thing works, will it make any money? If the answer is "No", in its present form, what possible combination of circumstances might be contrived to make the answer "Yes"? This involves study of new processes under development such as hydrogenation, Fischer-Tropsch, and the like, with the idea of assisting the people in charge of experimental research in selecting the most profitable channels of endeavor.

In this work we make preliminary chemical engineering designs. These form the basis for investigating investment cost, utilities consumption, etc., and enable us to determine the relative economic status of research which is in progress or contemplated. Typical of this work is a chemical engineering design and economic study for a complete 6500 b/sd Fischer-Tropsch unit which we made about two years ago, and which gave us a valuable insight into this process and its limitations in the present American economy.

Selection of Goal Important

Our work is concentrated on those problems in which the experimental research would be most affected. We believe it to be our job to devote engineering thinking to those features of process research that could be changed favorably if information were available to the directors of experimental work while the work was still in progress. For example, in our study of the Fischer-Tropsch process, we placed considerably more emphasis on the reaction section than we did on the product recovery section. This was for the reason that the things we found out about the reaction section had a definite bearing on experimental work in progress and our findings should be available at the earliest possible moment. On the other hand the only thing that would be accomplished on the product recovery side of the Fischer-Tropsch process through further study would be to cheapen the design, since no experimental work is contemplated on this. This we believe could better be done at a later date if and when construction of a Fischer-Tropsch plant becomes imminent.

While these designs have been called preliminary, they are nonetheless entirely practicable, investment cost being considered secondary to an operable design. The designs undergo revision and improvement as more data become available, but any given design represents what we believe to be the most economical and operable plant based on information then available.

Compared with Conventional

Now let us consider the question: How does process research engineering differ from ordinary process engineering? The only comparison that can be made between them is that both use engineering tools. Beyond that point the comparison ceases. It is much like building concrete buildings or building concrete roads. Both jobs would employ a cement mixer. However, the things produced are quite different. It is the function of a conventional process engineering group to design, study the economics of, and build commercial plants. Their proper outlook is one of conservatism. Usually, it is their job to look at every proposed plant with the question: "Is this necessary?" Most of their work is on projects that are not only necessary but technologically well-established. On the other hand it is the function of a process research engineering group, which is supposed to be aiding in the development of processes, to explore unusual process conceptions and to make sure that they do not stop research on a project through their recommendations unless it is clearly evident that the project is a definite failure economically.

Process research can be likened to a triangle with the initial phases of the work constituting the base and proceeding toward the apex in the distant future. The apex is not reached until the process has long been in commercial operation. This represents the ultimate in development. Research in progress is not a point or a line but a broad channel. As the work proceeds the channel narrows down. It is the function of process research engineering to mark the channel but not stop the boat.

Patents Can Be Obtained

Since process research engineering is conducted while the research is still in progress, it is possible to obtain many patents that would not otherwise be possible. If a company delays its engineering studies until the research is substantially completed, many of the best patents in the field will have gone to its competitors.

Each member of our staff strives to have some function in which he excels. For example, as a part of the data correlation work a Technical Data Book has been prepared which is widely used throughout the organization. This book presents correlations of the best physical data available. We consider it an important work and one which requires the frequent attention of a capable and discriminating man. The man in charge of our Technical Data Book does a considerable amount of process design so that he will be in a position to know just what a Technical Data Book should include. It is no more correct to give an incapable man charge of the technical tools than it is to use a poor machinist as a tool maker. The man in charge of our Technical Data Book has been chosen with the idea that we want one of our best "machinists" as a tool maker and he does enough "machine work" to know what kind of tools we will require.

Another man makes preliminary market studies on new products for which we are developing economic evaluations. Most of our economic evaluations are concerned with new ways of making products for which fairly well-established prices exist, but in some cases both the product and the process are new. In that event it is necessary to arrive at some idea of the volume of product which could be sold at a given price in order to complete the economic evaluation. The man in charge of market analyses keeps files of price data on unusual products and maintains contacts which enable him quickly to develop necessary information on contemplated new products.

Staff Assignments

Similarly another member of the staff—one experienced in design work—has the assignment of keeping our design procedures up-to-date and standardized, and another acts as the source and repository for all data of an economic nature. Another man specializes in correlation procedures and the statistical treatment of data. Each member of the staff "doubles in brass" and at various times may do every one of the operations of the section. No report goes out which has not been checked by two or more members. Collaboration is encouraged to the utmost on the theory that the correlated intelligence of a group of reasonably bright people will far surpass that of any single individual, however brilliant.

In conclusion, then, process research engineering is a specialized auxiliary to research management which enables extracting the maximum value from experimental results through data correlation; and which aids in choosing the most promising ideas for development and the most promising routes of procedure through engineering and economic evaluation.

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Test Data Meager from Five Years Of Synthetic Fuels Research

By V. B. GUTHRIE, Editor

RESULTS to date in the Bureau of Mines research in synthetic liquid fuels are set forth as part of the annual 1949 report of the Secretary of the Interior.(1) This is the program assigned to the Bureau in the spring of 1944, and for which Congress has appropriated $60,000,000 to carry the work through 1952.

The 1949 report describes in some detail the test work being done in the large-scale demonstration plants the Bureau has installed, using oil shale and coal as raw materials. Heretofore the work reported on has been mainly in the laboratory and pilot-plant stage. Actual operating and yield data from the test runs in the demonstration plants is almost entirely lacking in the current report. Such data would be of great value to the technologists in the petroleum industry, and others, in assaying the real progress the Bureau has made over the past 5 years in arriving at practicable methods for making liquid fuels and other products on a commercial scale from shale and coal.

The report states, however, that the Bureau has accumulated a large fund of information regarding costs, and it goes into detail on the capital investment and daily operating charges required for an oil shale plant to produce 10,000 b/cd of crude shale oil and 8,840 bbls. of refined products. Table 1 shows the yield of products of such a proposed plant and Table 2 its capital investment.

The shale mining operation for which costs are given is based on an ideal site which the Bureau picked out near its present oil shale operations at Rifle, Colo. Costs for the retorting operations, it is reported, are based on a gas-flow process developed by the Bureau's technologists. This gas-flow process, however, is still in the pilot plant stage and has not yet been installed in the demonstration retorting unit at Rifle.

"The refining process adopted for the cost calculations", states the report, "consists of delayed coking of the crude shale oil followed by mild hydrogenation of the coker distillate over a catalyst. All the steps are well-known commercial operations that should offer few difficulties in application. The removal of sulfur and nitrogen is no longer a serious problem. The crude shale oil can be processed to give a high yield of the more valuable products boiling below 725° F."

Some refinery technologists do not share the Bureau's confidence that there are no longer any serious problems to be encountered in refining the raw shale oil with its high sulfur and nitrogen content.

The Bureau's estimated operating cost for mining, crushing, and conveying the raw shale to the retort stock pile is 58.6c a ton. This includes management, overhead, depreciation, taxes and insurance.

In this proposed commercial venture the Bureau would dispose of the waste shale by dumping it in the canyons of the oil shale region. This favorable condition would not be true for all shale oil plants, however. One oil industry authority has estimated that if we ultimately obtain 365 billion barrels of shale oil, enough ash would be left to cover the entire state of Colorado to a depth of 10 ft.

Table 3 shows the operating costs for the 10,000 b/d shale oil plant, as set forth in the Bureau's report. The average cost of refined products (7.3c/gal.) is based on an output of 60% of what is termed jet fuels and does not include the cost of making finished gasoline. Assuming a return of approximately 6% a year and income taxes of 40%, would bring the cost of products to $3.77 a bbl., or approximately 9c/gal. as "the necessary refinery realization".

"It is not intended to suggest", states the report, "that this is the actual return that should be realized to attract capital, but rather to point out that oil-shale processing is not far from the point of commercial utilization."

The report also brings out that the sparsely populated area around Rifle could not absorb the products of a 10,000 b/d plant at the present time. Construction of a pipeline to marketing centers would increase the product cost by something less than 1 cent per gal. However, it states that five plants of 10,000 b/d each would have to be built to economically supply the pipeline.

Detailed estimates have previously been made by the Bureau of the capital investment and operating costs for a 30,000 b/d coal hydrogenation plant using Wyoming, N. Dakota, Montana, Illinois, or Pittsburgh seam coal or lignite.(2)

Pointing out that the net realization to a 30,000 b/d coal hydrogenation plant on the gasoline produced must be 14.5c/gal., the Bureau's current report states it is doubtful if such a plant would be an attractive commercial investment at present. It states, however, that only the sur-

TABLE 1—Daily Production of a 10,000 b/d Shale Oil Plant

Raw materials—Oil shale, tons	14,035
Crude shale oil, bbl.	10,000
Products—Jet fuel, bbl.	5,150
Diesel fuel, bbl.	3,350
Fuel oil bbl.	340
Total fuel, bbls.	8,840
Byproducts—Ammonia, tons	27
Coke tons	62.6

TABLE 2—Capital Investment for 10,000 b/d Shale Oil Plant

Section of Plant	Capital Investment(1)
Mining and crushing	$ 4,200,000
Retorting	7,468,000
General facilities chargeable to crude oil	2,280,000
Utilities chargeable to crude oil	1,989,000
Total—plant items for crude-oil production	15,937,000
Operating capital (10% of plant items)	1,594,000
Total for crude-oil production	$17,531,000
Refining	15,100,000
Pipe line (2 miles)	150,000
General facilities chargeable to refining	3,435,000
Utilities chargeable to refining	2,997,000
Total—refining plant items	21,682,000
Operating capital (10% of refining-plant items)	2,168,000
Total for refining	$23,850,000
Total capital investment	$41,381,000

(1) Amounts for plant items include interest at 3½% a year on invested capital during the construction period. Capital is assumed to be expended 10% in the first year, 50% in the second year and 40% in the third year.

face has been scratched so far in the development of processes for making synthetic fuels from coal.

Oil From Coal

A considerable portion of the annual report of the Mines Bureau on the synthetic liquid fuels program is devoted to the work at the Louisiana, Mo., station in the manufacture of liquid fuels from coal.

The 200-300 b/d coal hydrogenation plant built there was turned over to the Bureau by the contractors on Jan. 31, 1949. The plant was designed for two major operations using pressures up to 10,300 psi.: (1) liquid-phase hydrogenation, to accomplish liquefaction of the coal, and (2) vapor-phase hydrogenation, to convert the liquid coal to gasoline and by-products. The design of the plant has been earlier described.(2) Short test runs were made during the year on this plant using various charging stocks, part of it being a coal paste containing 25% of Wyoming bituminous coal. Under current plans a variety of coals from other fields are to be tested in the plant.

Design work on the second oil-from-coal demonstration plant at Louisiana has been completed and construction is under way. This is an 80-100 b/d gas synthesis plant, in which coal will be gasified and liquid fuels and other products produced from the synthesis gas. Construction of this plant was estimated to be 70% complete by Dec. 1.

Very meagre data is contained in the report from any of the runs on the hydrogenation plant. The charge to the vapor-phase unit during the petroleum hydrogenation run in April was made up of a blend of 61° API straight-run gasoline, 31% of 47° API naphtha and 58% of 39° API gas oil. A total of 29,360 gals. of this blend with 2,960 M cu. ft. of 95% hydrogen makeup gas was charged during the four-day run.

Hydrogenation at temperatures above 720° F. produced a light product higher than 70° API. Pressures varied from 9,715 in the recycle compressor to 10,000 in the recycle discharge. Products and yields obtained were 15,725 gals. of 66° API gasoline, 5,840 gals. of 48° API wash oil (naphtha), 4,280 gals. of 43° API bottoms and 975 Mcf of off-gases. The high losses were reported due to a leak that developed during the run and an accurate material balance could not be made.

The feed vapor-phase hydrogenation stock was then changed to a lignite-tar distillate oil in order to produce a specification Diesel fuel. This stock was prepared from a 10° API N. Dakota lignite tar oil by removing the low-boiling portion and the asphaltic material unsuitable for hydrogenation. The portion used represented 70% of the raw oil and had a gravity of 12° API. The total charge on this run was made up of 12,225 gals. of lignite-tar distillate, 5,480 gals. of petroleum oils in the system and 2,930 Mcf of hydrogen makeup gas. The range in pressures was from 9,690 psig. in the recycle compressor to 10,550 psig. in the hydrogen feed and maximum temperature was 730° F. in the preheater outlet.

Products and yields were: 8,835 gals. of gasoline, 615 gals. of wash oil, 4,520 gals. of Diesel fuel oil, 520 of slop oil and 955 Mcf of off-gases. Losses were described as very high and due to the same cause as in the April run. The bottoms from the product distillation were finished for Diesel fuel oil. This fuel was used on a 200-mile trial run in a Diesel electric locomotive hauling an 8-car passenger train to and from the plant during the dedication services in May. The fuel was widely heralded as the first "Diesel oil made from coal from the Bureau of Mines coal to oil demonstration plants".

The liquid-phase hydrogenation unit is described as being in continuous operation from Oct. 12 to Dec. 6. Coal-tar oil was circulated through the unit, at normal pressure and with a preheat outlet temperature of 450° F. for the first three weeks. From Nov. 10 to 17 the plant was operated to hydrogenate tar oil at 850° F. in the converters to produce naphtha-wash oil, middle oil flushing oil and some light-oil bottoms. Data on operating conditions for one day's run is submitted.

The high temperature coal-tar oil charging stock was replaced with a coal paste containing 25% bituminous coal from Rock Springs, Wyo., the run ending Dec. 6, when the unit was shut down for cleaning, necessary repairs and changes. No operating or yield data from the test run on the liquid-phase unit are presented.

The Linde-Frankl oxygen plant, a part of the gas-synthesis demonstration plant under construction at Louisiana, after trial operations early in 1949, started a regular scheduled period of operations Aug. 8. Data covering the period from Aug. 8 to Oct. 1 showed 1,175 tons of oxygen produced at the average rate of 22,600 cu. ft./hr. The results were said to compare favorably with those for the same plant during its operation in Germany.

The Koppers-type coal gasifier, the second completed unit of the gas-synthesis plant, was completed in May and made 36 test runs during the year to overcome operational difficulties. Under present conditions of operation, it is stated, approximately 1,260 lbs. of process coal and 10,500 cu. ft. of oxygen would be required to produce 1 bbl. of synthetic fuel. Estimated requirements based on the preliminary design were said to be on the order of 840 lbs. of coal and 9000 cu. ft. of oxygen. No operating data are given but it is stated that, when normal operating temperatures were obtained, virtually no tarry material was produced and the complex sulfur compounds were substantially destroyed. Construction of the gas-purification section of the unit is well advanced and the section is scheduled to be put into operation as soon as the gasifier is functioning in a routine manner.

Construction work on the synthesis and distillation units of the gas synthesis demonstration plant was started in May. Modifications and additions to the original design of the gasification-process flow include: a

TABLE 3—Operating Costs for 10,000 b/d Shale Oil Plant

Item	Cost/day	Cost/bbl.
COST OF CRUDE OIL		
Costs of operation and maintenance		
Mining and crushing	$ 6,005	$0.600
Retorting	3,056	.306
General facilities chargeable to crude oil	852	.085
Utilities chargeable to crude oil(1)	966	.097
Total direct cost	$10,949	$1.085
Fixed costs (depreciation,(2) taxes, insurance)	4,125	.412
Total cost of crude shale oil	$14,974	$1.497
COST OF REFINED PRODUCTS		
Refining operation and maintenance		
Refining	$ 6,705	$0.758
Pipe lines	54	.006
General facilities chargeable to refining	1,211	.139
Utilities chargeable to refining(1)	1,800	.215
Total direct refining costs	$ 9,880	$1.118
Refining fixed costs (depreciation,(2) taxes, insurance)	4,477	.506
Gross cost of refining	$14,357	$1.624
Cost of crude shale oil	14,974	1.694
Gross cost of refined products (average of 7.90 c/gal.)	$29,331	$3.318
Less byproduct credits:		
Ammonia at $75/ton	2,025	0.229
Coke at $5/ton	188	.021
Net cost of refined products (average of 7.30 c/gal.)	$27,118	$3.068

(1) Includes water, steam, and electricity at prices adequate to cover cost of maintenance and operation, depreciation, taxes, and insurance on utilities.
(2) Based on expected life of individual units of mining and crushing equipment, giving average depreciation of 13.5 %/yr., and 15-year payout (6.2/3 %/yr.) for other plant items, except utilities.

TABLE 4—Summarized Estimated Plant Costs of a 16,500 b/d Petroleum Residual Hydrogenation Plant

	Equipment	Other Mat'l.	Labor	Indirect(1)	Contingent	Fee	Total
Hydrogenation	$6,466,000	$2,770,000	$1,950,000	$1,625,000	$1,285,000	$704,000	$14,800,000
Hydrogen production	4,862,000	2,010,000	1,970,000	2,084,000	1,010,000	554,000	12,490,000
Distillation and gas recovery	640,000	521,000	432,500	398,600	198,500	111,400	2,300,000
C_3—C_4 storage			(@ $36.70/bbl. total erected cost)				387,000
Feed and product storage			Available in existing plant				
Utilities distribution (elec., steam, air, gas and water, incl. cooling towers)	1,310,000	520,000	742,000	670,000	324,000	177,000	3,743,000
Start-up cost							400,000
Total							$34,100,000

(1) Includes indirect field costs, engineering, overhead, and purchasing costs.

solids knockout chamber in the product gas line to protect the blades of the gas exhauster; nitrogen drier to insure thorough dryness for the inert blanket on the pulverized-coal bin, and an auxiliary steam superheater and feed piping to permit the intimate injection of steam into the oxygen-coal mixture.

Recognizing that supplies of heavy fuel oil were becoming burdensome to some refiners, an engineering study was conducted at the Louisiana station in 1949 into the upgrading of petroleum residuum into more marketable products. The study was made for the hydrogenation of 16,500 b.cd. of heavy petroleum residuum to produce 50-cetane Diesel fuel and motor gasoline. The design was made with a combined liquid and vapor-phase stall and the liquid and vapor-phase converters were to operate in series without pressure letdown in order to permit efficient utilization of the heat of reaction by heat exchange and improved heat economy.

Total cost of a 16,500 plant to hydrogenate petroleum residuum was given as $34,100,000, with the following payout times based on plant location; California area, 4.4 to 5.7 years; Atlantic Coast, 5.6 to 7.9 years; Mid-Continent area, 4.6 to 6.0 years. Fig. 1 is the Bureau's flowsheet and material balance for a plant to hydrogenate residual fuel oil. Table 4 is a summary of estimated costs for such a plant.

The work of the Bureau's coal-to-oil laboratories and pilot plants at Bruceton and Pittsburgh during 1949 was concerned chiefly with the development of new or improved processes related to the production of liquid fuels from coal.

Underground Coal Gasification

Part of the work of the Mines Bureau in the field of producing synthetic liquid fuels from coal is the intensive search for a coal-gasification process that might materially reduce the cost of the synthesis gas-hydrogen and carbon monoxide required. This work is carried on in laboratory and field tests at Morgantown, W. Va., and Gorgas, Ala.

On Mar. 18 at Gorgas, the Alabama Power Co. and Bureau technologists put into operation their second cooperative experiment in the underground gasification of coal. Two parallel entries were driven into the coal bed for 1200 ft. and a single entry for an additional 300 ft. At crosscuts linking these entries, the underground workings were connected with the surface by five large boreholes through which compressed air may be admitted or product gases withdrawn. All operations thus far, it was reported, have been conducted in the 300-ft. single entry. No difficulty in maintaining combustion was reported. Approximately 300 tons of coal have been burned.

No emphasis was placed on quality of gas during these initial operations, for the essential objective was considered to produce a gas and then to exercise quality. If a producer gas is obtained, it was said, the quality may be improved through the use of oxygen and steam, with the aid of fluid catalyzers. With regard to the success of this experiment, the Bureau report states:

"At times, under proper conditions, the calorific value of the products gas has been high enough to make it combustible. However, owing to the by-passing of air through void spaces underground and subsequent combustion of the product gas before removal from the system, the energy content of the coal as brought to the surface has been largely in the form of sensible heat. This could be used, of course, for generating steam at the system outlets. There is evidence that a good-quality producer gas is being made along the burning coal ribs, but it has not yet been possible to recover such gas."

At Morgantown, pilot plants employing other principles for the coal gasification were in operation. A pilot plant is being constructed to gasify 500 lbs. of coal hourly at pressures up to 450 psig.

Oil From Shale

Principal experimental work of the Mines Bureau in producing liquid fuels is carried on at Rifle, Col., where shale is mined, retorted to extract the oil and the oil refined in a demonstration shale-oil refinery. The refining unit consists of a thermal cracking plant and continuous acid-treating and doctor-sweetening unit. The refinery was first placed in operation in July, 1949.

The experimental mining operations are conducted in an exposed cliff of shale called the Mahogany Ledge, the entire area of which is estimated to be capable of yielding 100 billion bbls. of shale oil, and

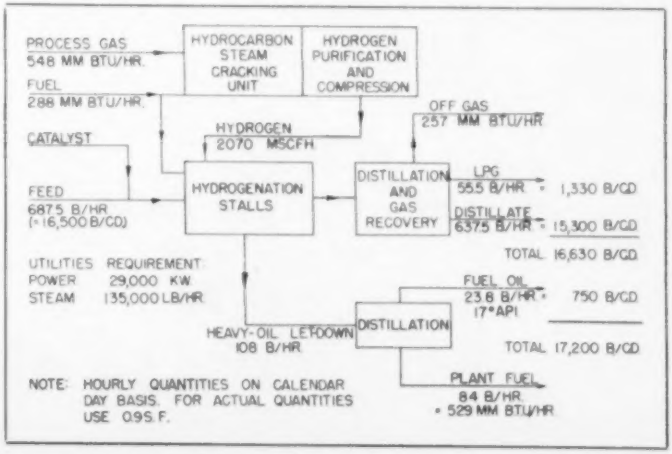

Fig. 1—Flow sheet and material balance of residual-oil hydrogenation plant

is considered by the Bureau to be of prospective economic importance for the establishment of an oil-shale industry in the relatively near future.

Mining operations were carried on in 1949 in two sets of workings, driven into the vertical cliffs of the shale deposit, 3000 ft. above the site of retorting and refining operations, and reached by a mountain road 5½ miles long.

The Selective Mine had been developed earlier to produce shale from any one of the 8 divisions of the Mahogany Ledge. With the further development of the Underground Quarry, operation of the higher-cost Selective Mine was curtailed in April, 1949.

Prior to midyear 1949, work on the Underground Quarry was centered first on determining fundamental mining data needed for the design of efficient shale mining equipment and, second, on designing and procuring this equipment. By August the full complement of equipment necessary for a one-unit, commercial-scale operation of the Underground Quarry had been designed and procured. Two 4-week test runs in the Underground Quarry were conducted in 1949, operating procedures being identical with those that would be employed in one unit of a commercial mine. In the course of the experimental oil shale mining at Rifle in 1949, 133,600 tons of shale were mined in the Underground Quarry, and 10,360 tons in the Selective Mine.

A recommended layout and estimate of costs for mining oil shale to supply a 10,000 b/d shale oil plant was made in 1949. A representative mine location has been selected for producing 14,035 tons of shale per day. The site chosen has an area of one square mile and a Mahogany Ledge 72 ft. thick, averaging 30 gals. of shale oil per ton. Within this area it is estimated that 102,000,000 tons can be mined, sufficient to supply a 10,000 b/d plant for 20 years. The estimated total cost of mining, crushing and conveying the shale to the retort stock pile is reported as 58.5c/ton, including management, depreciation, taxes and insurance.

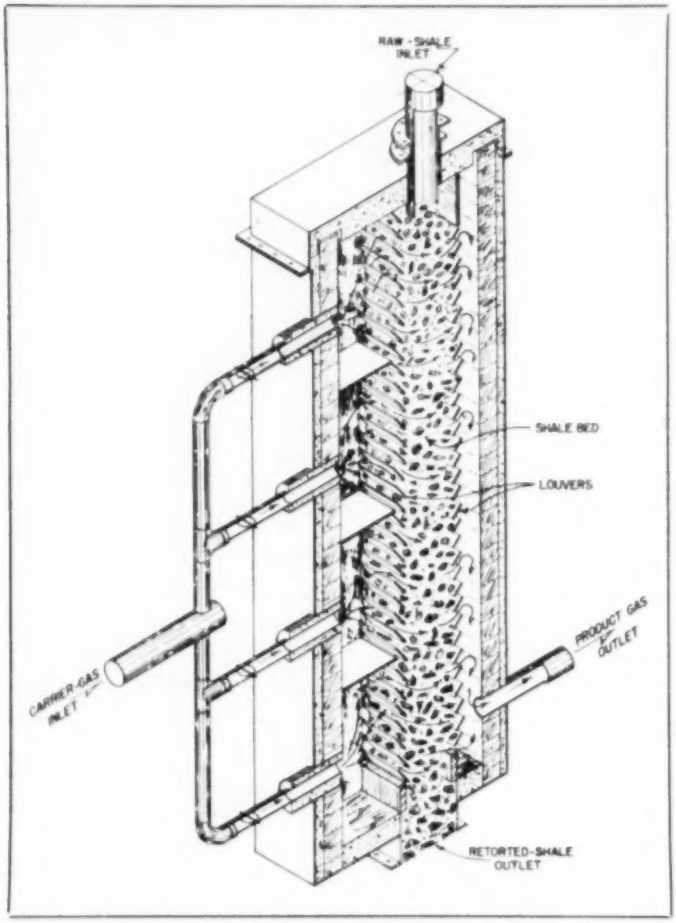

Fig. 2—Gas-flow retorting vessel

Experimental N-T-U oil shale retorting operations were begun at Rifle in 1947 and were completed early in 1949. In July a 10-day demonstration run was made to obtain oil production data. Since that time the retorts have been in operation to supply plant oil requirements. The N-T-U retorting plant consists of two identical 40-ton charge capacity units with auxiliary product recovery and storage systems.

No yield or operation data are given on the N-T-U operations. The report states that, during a 10-day period under optimum conditions the retorts were charged with 1561 tons of oil shale assaying 33.7 gals./ton. During this period 77.6% recovery was obtained. The retorts are now said to be producing shale oil for boiler fuel at less cost than commercial fuel can be obtained at this remote location.

Test work in the pilot plant stage was carried on at Rifle in 1949 on a gas-flow retorting process being developed by the Bureau. In this process a continuous weighed and sampled stream of raw shale enters the top of the retort through a rotary-gas seal. Fig. 2 shows the gas-flow retorting vessel. Kerogen conversion proceeds within the rectangular retort vessel through which the shale flows by gravity as a moving bed of particles.

A circulating stream of product gas, raised to retorting temperature in the gas heater, enters the retort through a gas-distribution manifold and flows transversely through the moving shale bed, which is bound on two sides by louver bars. The inlet-gas manifold directs the circulating gas stream to various portions of the shale bed, thereby controlling the temperature gradient from the top to the bottom of the retort. The spent shale is discharged from the bottom of the retort by a vibratory feeder which controls the shale throughput rate. Shale is moved from the vibratory feeder to dump cars by a drag chain conveyor.

The circulating gas stream, together with gas and oil products and water produced during the retorting, passes to a scrubber where part of the product oil is condensed and entrained particles of shale removed. The overhead gas flows to a tube and shell condenser where the water and remaining oil are condensed. The required gas for retorting is re-

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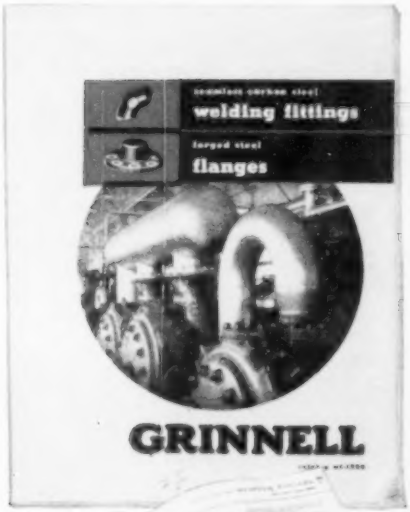

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cycled back to the retort and the excess vented.

With this process, while retorting shales assaying below 45 gals. /ton of shale, a major operational difficulty is an accumulation of coke on the downstream louver bars, causing a stoppage of gas flow through the shale bed.

The new demonstration shale oil refinery at Rifle was placed in operation in July. It was designed for investigating atmospheric distillation and most of the conditions employed in thermal cracking, including visbreaking, coking, recycle cracking of either crude or distilled stocks, and reforming, the Mines Bureau report states. The plant can produce motor gasoline, Diesel fuel, distillate and residual fuels, and coke, as well as stock for additional processing.

Treating facilities at Rifle are designed to remove the tar acids and tar bases from the gasoline and Diesel-fuel fractions. These stocks are treated with concentrated sulfuric acid at controlled temperatures principally for the reduction of nitrogen, sulfur and gum and color forming constituents. Crude tar acids and tar bases available from treating operations are said to offer economic by-product possibilities.

The treating plant consists of a continuous low-temperature, three-stage, countercurrent sulfuric acid treater. The distillation and cracking unit is actually a single unit. The cracking plant has been operated for one or more runs on atmospheric distillaton, visbreaking and recycle cracking of crude shale oil, and, as the report was written, refinery runs were underway on coking crude shale oil.

The report states that recycle cracking of total crude shale oil appears to have possibilities for producing gasoline while making liquid residual fuels. The gasoline is said to have a reasonably good boiling range and satisfactory octane, while the residuum meets the usual specifications for bunker fuels.

The Mines Bureau report does contain some data on operating conditions of the cracking plant on atmospheric distillation, visbreaking, recycle cracking and coking, as well as data on sulfuric acid treatment of light gas oils and shale-oil gasoline. With regard to the nature of the Rifle refinery operations to date, however, the report states:

"The cracking and distillation investigations to date constitute little more than a trial run on each of the operations reported. Since most of these operations involve different items of equipment, the first run on each was for the purpose of determining operability and the data obtained were incidental.

"In some cases it has been possible to determine some of the limiting conditions but in no instance have optimum conditions or trends been defined. Data represents actual results but it is possible that many variations and discrepancies will be found later.

"Treating plant operations so far have been exploratory and much work remains to determine optimum conditions."

The Bureau of Mines work in extraction of liquid fuels from oil shale also includes work in laboratories and pilot plants at Laramie, Wyo. The composition of oil shale and shale oil is being studied as well as methods of processing and utilizing these materials.

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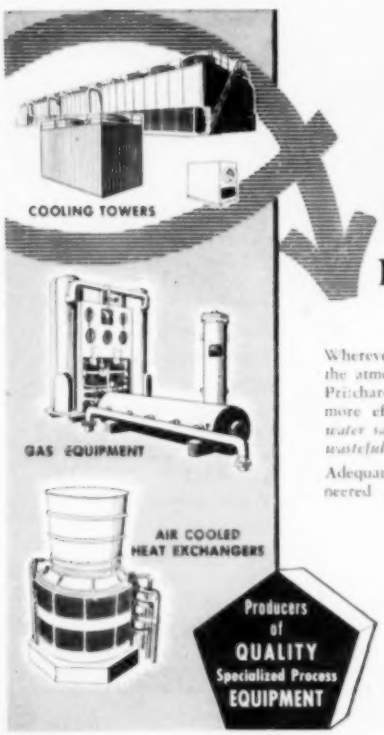

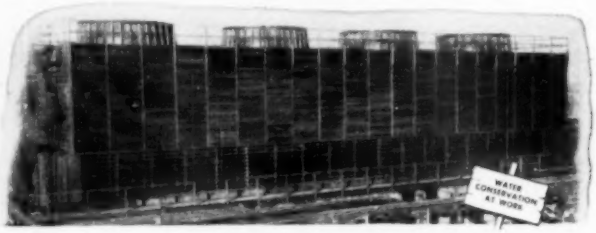

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Gulf Oil's Flare Stacks Are Designed To Solve Three Important Problems

WASTE gas flare stack design, as developed by Gulf Oil Corp., has been done with three factors in mind: 1) safe and efficient pilot burners, 2) protection of operating personnel, and 3) long service life from the flare tip itself.

All sections exposed to heat and gases are protected by the use of alloy materials of construction and refractory linings. Sour crudes have been run on one of the company's units for several years, but the use of stainless steel has eliminated any troubles from corrosion. Smog has not been a problem. The gas allowed to escape to the flare is only during an emergency. With only a pilot burning on the flare and the combustion being complete on this pilot, no carbon is liberated to cause smog.

Gulf has employed burning pits to some extent. However, where flare towers have been installed, the burning of waste gases at ground level has been discontinued and all emergency venting of gases is handled at the flare tower.

General construction details of the company's latest design for a flare tip are shown in the sketches in Fig. 1. The 20-in. diameter stack is fabricated of $\frac{3}{8}$-in. carbon steel except for the top $3\frac{1}{2}$-ft. section, which is 3/16-in. stainless steel.

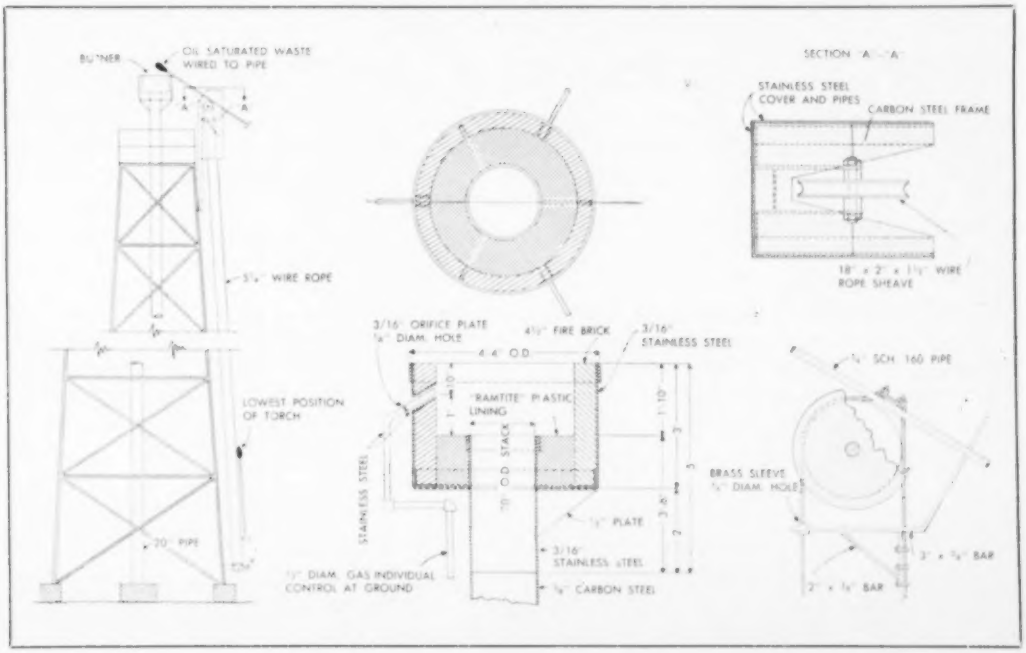
The burner proper consists of a 4 ft., 4 in., diameter cylinder of 3/16-in. stainless steel, supported on three $\frac{1}{2}$-in. thick, triangular steel gussets. It is lined with $4\frac{1}{2}$-in. fire brick around the side walls and a "Ramtite" plastic refractory lining on the bottom, 14 in. deep. Three openings are provided in the side walls for the three stainless steel pilots.

Fig. 1—Construction details and arrangement for emergency lighting of Gulf Oil's waste gas flare stack and tip design

Gulf engineers state the arrangement has given satisfactory service with a minimum of gas being used by the pilot. Usually only one of the three pilot burners is required, and at times it is difficult to see the flame of the pilot from ground level.

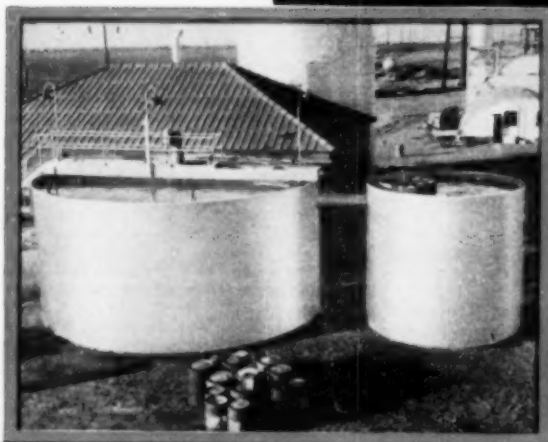
Protection of the emergency lighting mechanism has been found essential. Details are illustrated at the right in Fig. 1. The upper sheave and upper portion of the cable is protected by the stainless steel shield. This keeps the flame away from the sheave, sheave bearings, and cable. It also reduces the temperature to which these parts are subjected.

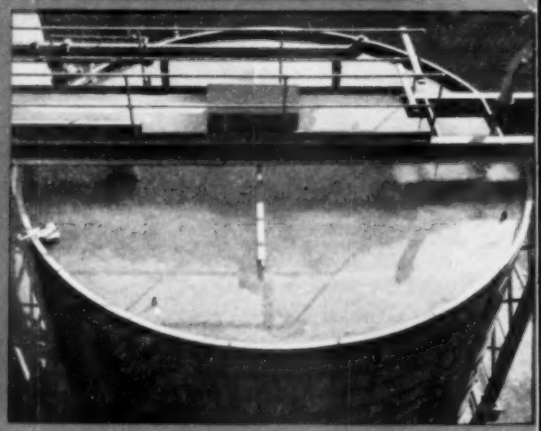
The cable carrying the lighting torch is 7 x 19 stainless steel. Gulf previously used plow steel cable and bronze tiller rope, which was subject to failure in several instances. The cable tends to deteriorate from the high temperatures at the upper level of the tower if it is not made of temperature-resisting alloy with a hard center. The cable is changed



COCHRA

ECONOMICAL REMOVAL OF IMPURITIES FROM INDUSTRIAL WATER SUPPLIES – TURBIDITY, COLOR, HARDNESS – REMOVAL OF SUSPENDED SOLIDS FROM WASTE





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The Cochrane Sludge Contact Reactor is distinguished by the fact that the sludge bed is always in suspension, so that the sludge is always present when chemicals and water react.

This is important, in that the precipitates or sludge must not be allowed to settle out on the floor of the tank if maximum clarification or softening is to be obtained. The water as it rises through the sludge bed is both treated and filtered.

Cochrane Sludge Contact Reactors are applicable to

1. Municipal and industrial plants for coagulation and/or softening, removal of turbidity, color, hardness, taste and odor
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3. Fluoride removal, de-alkalization, iron and manganese removal
4. Paper, textile and other plants for process water—recovery of fibre stock and filler from white water

NEW PUBLICATION AVAILABLE

A new bulletin describing the Cochrane Sludge Contact Reactor, and illustrating different applications is just off the press. A copy will be sent on request.

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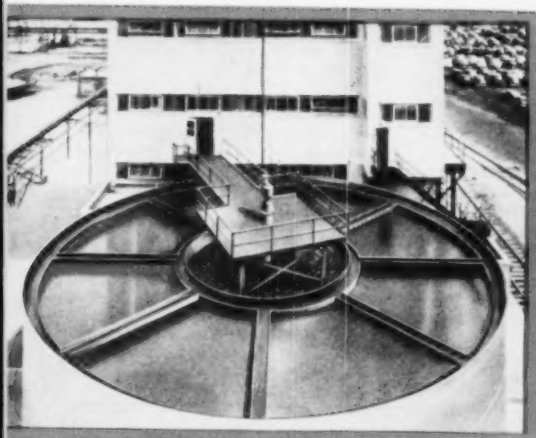

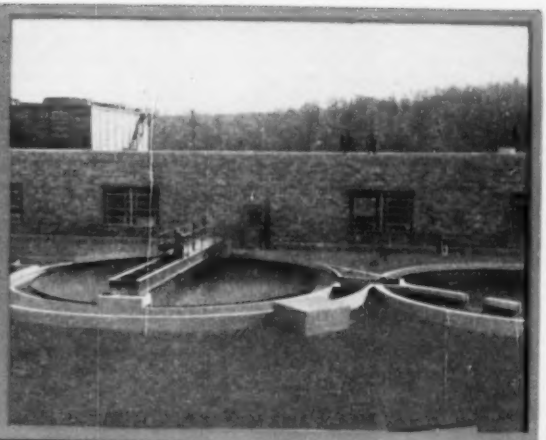

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[To obtain more data on advertised products see page 536]

yearly regardless of condition, and usable sections are salvaged for other jobs.

A protective grating has been installed at the base of the stack for the safety of the operator during use of the emergency lighting torch. This was installed after a cable broke, allowing the torch to fall at the normal position of the operator.

Refinery Develops Improved Procedure For Removing Coke from Soaker Drum

IN the past, the removal of coke from refinery vessels at a large northern Illinois plant which were coked up solid has been accomplished through the use of a home-made drilling apparatus. This home-made drilling apparatus consisted of an air motor, drill points, and short sections of shafting.

The drilling was done through the bottom manway of the tower. Two bars were attached to the air motor and it was suspended from the bottom of the tower by two chain blocks. As the drilling operation proceeded, the drilling rig was pushed up into the coke by taking up on the chain blocks. As needed, sections of shafting were added to the drill shaft.

After the first small hole was drilled through the coke bed, it was enlarged by using several increasingly larger bits until a hole approximately 12 in. in diameter was made through this bed. Workmen then entered the top of the vessel through the top side manway opening. The coke was dropped through the hole previously drilled. The workmen inside the tower were supported on a collapisible swinging scaffold as shown in Fig. 2.

This scaffold consists of a small wooden platform 3 ft. square suspended by block and tackle from a 4 x 4 in. timber placed across the nipple at the top of the tower. The scaffold is collapsible and can be pushed through the manway of the tower and assembled inside. A safety chain is also suspended from the 4 x 4 in. timber at the top of the tower and men working on the platform wear a safety belt which can be fastened to this chain at whatever elevation they happen to be working.

In case the towers being cleaned have too much coke on their inner walls and will not permit the use of a 3 ft. square scaffold, then a 2 ft. square scaffold is used similar to the type shown in Fig. 2.

The aforementioned method of coke removal was found to be slow and inefficient because of the difficulties encountered during the drilling operation. At times it took 24 to 48 hours to drill a 12-in. diameter hole through the coke bed. Since there was no means to guide the drill bit straight up through the bed, it frequently bent off to one side or channeled through a soft section of coke. This caused the shaft to frequently break when it became misaligned, thereby causing delays in fishing out the bit and starting over again.

In order to overcome the aforementioned drilling difficulties, new coke drilling equipment which consists of the following items was developed.

One air motor, complete with extra blades and shaft wrench.

Two special 5½-in. diameter carbide tipped drills.

Fourteen 4 ft. sections of 1-in. pipe with special steel couplings. These special steel couplings have an outer hexagonal body which can be gripped with a suitable open end wrench. This feature aids the coke drilling crews in the assembly and disassembly of the 4 ft. lengths of 1-in. extension piping. Eventually it is planned to use a coupling similar to the type now being used in the oil drilling industry. This coupling will have heavy tapered male and female threads with the male part welded to one of the 4 ft. lengths of 1-in.

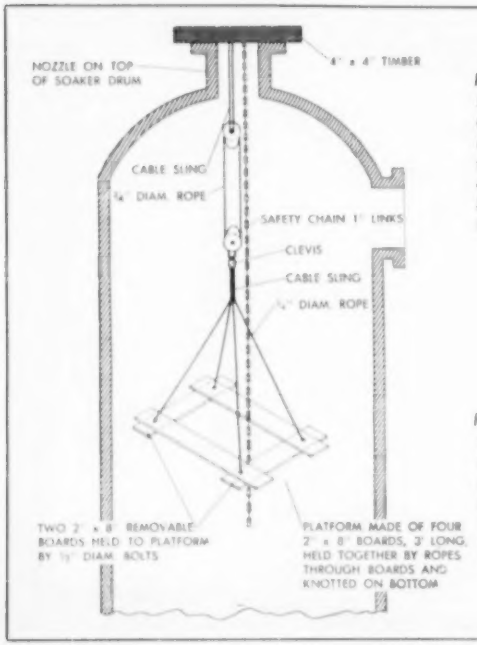

NOZZLE ON TOP OF SOAKER DRUM
4" x 4" TIMBER
CABLE SLING
¾" DIAM. ROPE
SAFETY CHAIN 1" LINKS
CLEVIS
CABLE SLING
¾" DIAM. ROPE
TWO 2" x 8" REMOVABLE BOARDS HELD TO PLATFORM BY ½" DIAM. BOLTS
PLATFORM MADE OF FOUR 2" x 8" BOARDS, 3' LONG, HELD TOGETHER BY ROPES THROUGH BOARDS AND KNOTTED ON BOTTOM

Fig. 2 — Left: scaffolding used for cleaning coking unit soaker drums after hole has been drilled through coke bed

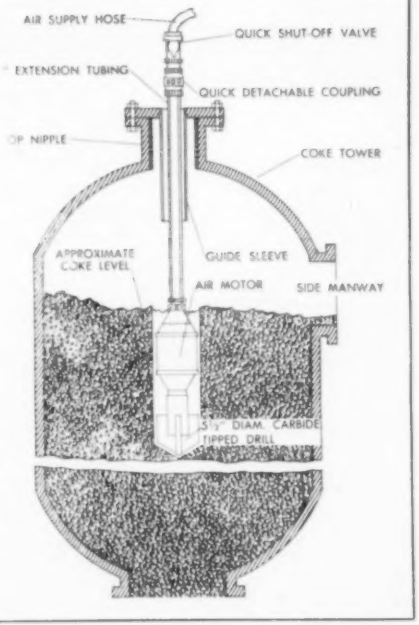


Fig. 3 — Right: new coke drilling equipment involves boring down through the coke bed from top of soaker drum

extension piping and the female part welded to the other end of the same extension piping. Each 4 ft. length of 1-in. extension piping will be so arranged as described above. The outer body of this coupling will be hexagonal in shape, which will permit the coke cleaning crews to assemble or disassemble these 4 ft. lengths of extension piping with only a few turns of a suitable open end wrench.

1—Quick shut-off air valve.
1—Suitable Universal joint.
1—8-in. Extension.
3—Stellited Drills.
1—Each suitable sleeve for a 6-in. and 8-in. Tower nozzle.

This new coke drilling equipment operates within the tower being cleaned as shown in Fig. 3. The $5\frac{1}{2}$ in. carbide tipped drill and motor enter the tower through the top nipple and a hole of approximately $5\frac{1}{2}$ in. in diameter is drilled completely through the center of the coke in the coked up tower. This hole is then enlarged through the use of a suitable chain knocker, or by progressively drilling through with a special $8\frac{1}{2}$ in. diameter and 12 in. diameter Carboloy tipped drill.

After the hole has been enlarged sufficiently to permit passage of the largest pieces of coke, workmen enter the tower through the top side manway, and supported on a swinging collapsible scaffold, proceed to break out the coke with suitable air tools. This coke is pushed to the drilled hole from which it falls out at the bottom of the tower and is then removed. This procedure is continued until all the coke is removed from the tower.

This new coke cleaning equipment has only been used a few times but it is considered more efficient and has given better results than equipment previously used.

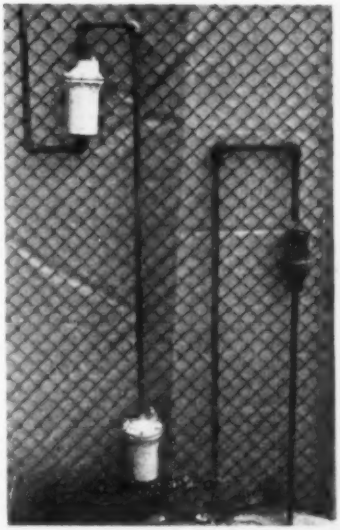
To date, in enlarging the $5\frac{1}{2}$ in. diameter hole, a chain knocker has been used. At present, there is on hand a special $8\frac{1}{2}$ in. and 12 in. diameter Carboloy tipped drill which will be used to enlarge the initially drilled hole and will replace the knocker previously used. Although these special drills have not been used as yet, it is felt that they will prove to be satisfactory in enlarging the initially drilled hole. These special drills are cone shaped and are arranged for attachment to the air motor. The $8\frac{1}{2}$ in. drill has five cutting blades equally spaced around the sides of the cone. The cutting blades are bolted to the drill head and the cutting edges are tipped with Carboloy. The 12 in. drill is similar in construction.

It has been estimated that at least two shifts of work have been saved through the use of this new coke cleaning equipment and this can go as high as ten shifts, depending upon the condition of the coke in the tower being cleaned, as well as the efficiency of the new coke cleaning equipment. Part of this saving in work is due to the setting up and handling of the new equipment.

Steam Trap Operates Sump Pump

A SIMPLE, steam trap-operated sump pump, developed by Socony-Vacuum Oil Co. engineers and in use at the Paulsboro, N. J., refinery, is illustrated in the accompanying photograph of a sample arrangement. It utilizes a steam trap, two check valves and a small pot (which in this sample, is an empty steam trap body. It may be a short piece of pipe with welded heads.)

The condensate discharge from a normally operating steam trap (upper trap shown) is piped into the receiving pot (empty trap shown in the lower position). The pot and two check valves may be installed in a sump near the operating steam trap. The power of the condensate discharge from the normally operating trap is sufficient to operate both check valves and keep the sump drained.



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- Applied by brush, roll, spray or dip methods.
- Finish coat in eight colors.

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Patent Trends in Petroleum Refining

By Peter J. Gaylor, Editor "The Technical Survey"

Socony-Vacuum Discloses Synthetic Lubes from Olefins

At a recent meeting of the American Chemical Society, disclosure was made by F. M. Seger, research chemist of Socony-Vacuum Oil Co., of synthetic lubricant production from 1-decene and similar hydrocarbons.(1) These products are claimed to have all of the desirable qualities of high grade lubricants. They also are claimed to exert a solvent and cleansing action on gums produced by ordinary oils. Lubricating oils of any density were claimed to be produced by properly adjusting operating conditions.

A series of patents were issued recently to this company on the subject. In U. S. 2,500,159, normal, alpha-monoolefins of 8-12 carbon atoms, such as 1-octene, 1-decene, etc. are subjected to polymerization in the presence of hydrogen, carbon monoxide, or mixtures of the two gases, at about 700°-900° F. and 1000 psi., in the absence of catalysts, to produce 30-63 wt. % yields of synthetic lubricant.

In the case of 1-decene, using a gas comprising 400 psi. carbon monoxide and 600 psi. hydrogen, a 63.3% yield of synthetic lubricant was obtained having a viscosity at 100° F. of 13.41 cs., and 3.31 cs. at 210° F., the pour point being —15° F. Kinematic viscosity index of the oil was 134.3, bromine number was 17.3, while the Lovibond color was 1.0.

A thermal polymerization of 1-decene with minor proportions of styrene is disclosed in U. S. 2,500,160, while in U. S. 2,500,161 there is described a polymerization by heating with lead tetraacetate. In this case, 1-decene (2 mols) is charged into the bomb with 0.1 mol of lead tetraacetate, the air in the bomb is replaced with nitrogen, and the bomb is heated to 500° F. for 5 hrs. (when it reaches a pressure of 650 psi.). An 11% yield of lubricating oil is obtained with the following properties:

Vis. at 100° F., cs.	44.22
Vis. at 210° F., cs.	7.40
Viscosity index	132.6
Specific gravity	0.8423

In U. S. 2,500,166, thermal polymerization of decene 1 at 200-1000 psi. and 700°-750° F. is reported to give yields as high as 66% of synthetic lubricating oil of 141 viscosity index, —10° F. pour point, 16.6 bromine number, and 0.8398 specific gravity. When 2-octene is polymerized, an oil of 34.8 viscosity index is obtained, while 2-ethyl hexene-1 gives a 1.5% yield of lubricating oil of 51.7 viscosity index, showing the importance in using a normal 1-olefin. On the other hand, butene-1 gives a 3% yield of 35.8 V. I. oil, while hexadecene-1 gives a product of 75° F. pour point, thus showing the importance in selecting the proper number of carbon atoms per molecule in the olefin. Table 1 gives the properties of lubricants obtained by thermal polymerization of various olefins.

As can be seen from Fig. 1 giving data on 1-decene, higher gravity oils are obtained at higher polymerization temperatures, with reaction time for peak production becoming shorter as temperature is increased. However, viscosity index and yields are favored by lower temperature.

The production of low-pour, low cloud viscous oils with mono-olefins of 8-18 carbon atoms, reacted with styrene in presence of silica-alumina catalysts, is disclosed in U. S. 2,500,203. These products are obtainable in yields up to 91%, but they do not act as V. I. improvers in mineral oils, although they are claimed to have high V. I.'s and high stability.

Among the other patents in this group, U. S. 2,500,162 covers thermal condensation of a short chain monoolefin with a long chain monoolefin at 500-750° F. Polymerization of normal, alpha olefins of 5-18 carbon atoms at 600-750° F. in presence of a phosphorus sulfide is disclosed in U. S. 2,500,163, while 2,500,164 specifies use of an elemental substance such as sulfur, selenium and tellurium in the molar ratio (to olefin) of 0.01-0.15. Thermal polymerization of normal, alpha monoolefins of 6-14 carbon atoms to viscous oils in presence of minor amounts of a paraffin is covered in U. S. 2,500,165 The temperature may vary from 700° F. for 1-3 hrs., to less than 900° F. for 0.25-0.5 hr. In U. S. 2,500,167, the monoolefin of 5-18 carbon atoms is condensed, in presence of sulfur,

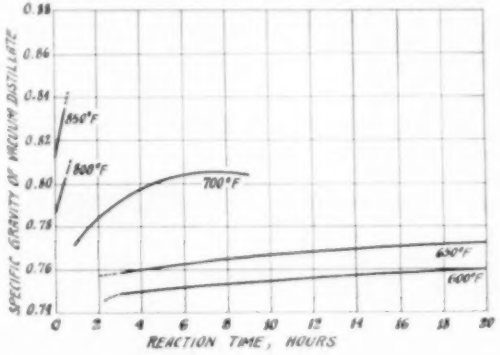

Fig. 1 — Effect of reaction temperatures on specific gravity of oils from 1-decene (Socony-Vacuum Oil Co.)

TABLE 1—Thermal Conversion of Other Olefins

Olefin	Temp., °F.	Time, Hours	Pressure Gauge	Yield	Viscosity @ 210° F.	V.I.	Pour Point	Bromine No.	Specific Gravity	Neut. No.
Propylene	610	10	1,500	5.9	30	...	<—30	62.8	0.7887	1.4
Do	650	10	2,400	8.5	43.6	—85	—25	46.9	0.9705	1.3
Butene-1	650	9	1,600	3.0	37.98	35.8	<—30	28.9	0.8462	10
Isobutylene[a]	650	10	2,325	2.8	43.79	<0	...	44.7	0.8822	...
Pentene-2	605	10	1,725	2.5	30	...	<—30	85.8	0.7778	1.2
Hexene-1	610	9½	900	9.9	37.67	85.0	<—65	29.5	0.8294	0.1
2-Ethyl hexene-1	650	9	1,150	1.5	34.04	51.7	<—30	51.7	...	1.95
Octene-2[b]	650	20	900	10.5	37.09	34.8	<—30	52.1	0.8607	1.0
C_8 Polymer[b]	640	9	600	1.74	....	....	...	....	....	..
Octene-1[c]	600	28	1,400	45.0	43.92	128.4	<—70	14.3	0.8338	0.1
Do	610	10	700	29.6	43.14	126.2	<—70	14.9	0.8413	0.2
Dodecene-1	600	10	250	50.0	45.18	152.6	+25	16.2	0.8294	0.2
Do	710	5	250	61.4	43.34	150	+45	15.7	0.8348	0.2
Hexadecene-1	660	11	200	84.8	50.47	146	+75	12.8	0.8368	0.3

(All reactions conducted in an atmosphere of N_2 unless otherwise specified.)
[a] Bomb evacuated to give no atmosphere other than isobutylene.
[b] Approximately 58% n-octene-2 and 42% n-octene-1.
[c] Mainly mixed nonenes of branched structure.
[d] Approximately 90% n-octene-1.

(1) *National Petroleum News*, 42, no. 13, 19 (Mar. 29, 1950).

selenium or tellurium, with a conjugated hydrocarbon, such as butadiene. A similar condensation in presence of a thiol (such as n-butyl thiol) is described in U. S. 2,500,672.

Steam Cylinder Oil

A SUPERIOR steam cylinder oil, covered in a Shell Development Co. patent, comprises a mineral oil free from asphaltenes and of a suitable viscosity, containing a minor proportion of an alkali metal salt of a rosin oil acid and 1-15% by weight of added petroleum resins. The salt is capable of spreading hydrocarbon oil on metal surfaces wetted by water (Can. 460,480).

Patents Issued in March

The following classified listing gives the patent number, patentee or assignee, and a brief description of all patents believed to be of direct interest to the petroleum processing industries, as contained in the Official Gazettes of the U. S. Patent Office for March 7, 14, 21 and 28, Vol. 632, Nos. 1-4.

Fuels

2,501,124 (Socony-Vacuum Oil Co.)—Jet combustion fuel containing some thiophene to lessen deposits in combustion chamber.

2,501,419 (Phillips Petroleum Co.)—Heater for liquefied gas.

2,501,678 (Standard Oil Development Co.)—Leaded motor fuels.

Conversions

2,500,235 (Sinclair Refining Co.)—Pyrolytic conversion of hydrocarbons.

2,500,307 (California Research Corp.)—Cyclic process for converting propylene to polymers.

2,500,482 (Shell Development Co.)—Catalytic dehydrogenation with Cr catalyst.

2,500,737 (Sinclair Refining Co.)—Fluid catalyst conversion.

2,500,755 (Standard Oil Development Co.)—Polymerization of cycle oil from high temperature steam cracking.

2,500,870 (Phillips Petroleum Co.) — Porous siliceous pebbles as catalysts.

2,500,920 (Phillips Petroleum Co.)—Dehydrogenation of aliphatic hydrocarbons with alumina-chromia-tungstia-vanadia.

2,500,938 (Houdry Process Corp.)—Diluting steam released during catalyst regeneration.

2,501,023 (Pan American Refining Corp.)—Hydrocarbon conversion with HF catalyst in homogeneous phase.

2,501,071 (Universal Oil Products Co.)—Isomerizing hydrocarbons.

2,501,197 (The Texas Co.)—Thermal conversion with sodium-free fluoride catalyst.

2,501,223 (Phillips Petroleum Corp.)—Treating Fischer-Tropsch gasoline by cracking and isomerization.

2,501,436 (Shell Development Co.)—Catalytic conversions with finely divided catalysts.

2,501,625 (Socony-Vacuum Oil Co.)—Methylation of isoparaffins in presence of HF.

2,502,00-1 (Socony-Vacuum Oil Co.)—Alkylation of aromatic hydrocarbons.

2,502,008 (Phillips Petrolem Co.)—Mobile catalysts in hydrocarbon isomerization.

2,502,015 (Phillips Petroleum Co.) — Alkylating isoparaffins with 2-olefins.

2,502,333 (Socony-Vacuum Oil Co.)—Preheated charge in HF alkylation.

Refining

2,499,365-70 (Petrolite Corp.)—Breaking petroleum emulsions.

2,499,820 (Shell Development Co.)—Thiourea-hydrocarbon complexes for hydrocarbon separation.

2,500,240 (Gulf Research & Development Co.)—Separation of gaseous mixtures by diffusion.

2,500,349 (Petrolite Corp.)—Breaking petroleum emulsions.

2,500,353 (Universal Oil Products Co.)—Fractionally separating mixture of normally gaseous components.

2,500,737 (Texaco Development Co.)—Removal of asphaltic constituents of oils.

2,500,916 (Phillips Petroleum Co.)—Controlling vaporization.

2,500,934 (Foster Wheeler Corp.)—Apparatus for stripping out volatiles from fluids.

2,501,015 (Petrolite Corp.)—Breaking petroleum emulsions.

2,501,064 (Standard Oil Co.—Indiana)—Separating aromatic and sulfur compounds in liquid HF-BF_3.

2,501,802 (Socony-Vacuum Oil Co.)—Refining highly aromatic petroleum stocks with formaldehyde and ammonium chloride.

Chemicals

2,499,377 (Standard Oil Co. Ohio)—Sulfonated dialkyl thioether.

2,499,505 (Sun Oil Co.)—Vinylcyclohexene hydrochlorides.

2,499,515 (Standard Oil Co.—Indiana)—Oxidation of aromatic hydrocarbons.

2,500,024 (California Research Corp.)—Aqueous detergent.

2,500,033 (Sun Oil Co.)—1,5 Pentanediol biscyclohexyl acetate.

2,500,082 (Standard Oil Development Co.)—Acylated derivatives of high molecular weight styrene-isobutylene copolymers.

2,500,136 (Standard Oil Development Co.)—Oxygen separation.

2,500,210 (Standard Oil Development Co.)—OXO synthesis catalyst.

2,500,256 (Phillips Petroleum Co.—Nitriles by reacting olefins with ammonia.

2,500,329 (Standolind Oil & Gas Co.)—Azeotropic distillation of 1-butanol from methyl-n-butyl ketone.

2,500,385 (Universal Oil Products Co.)—Preparing nor-camphor.

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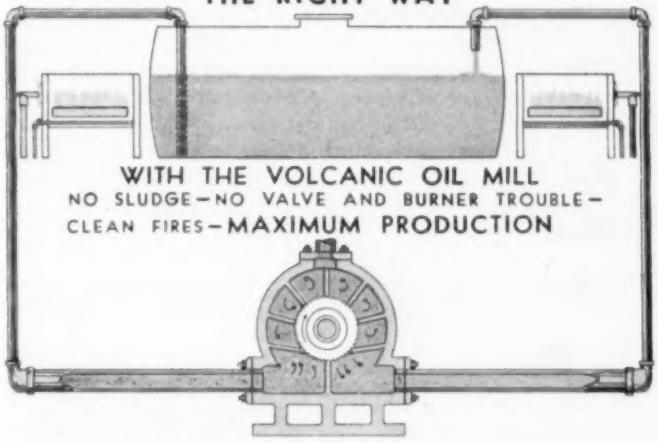
THE RIGHT WAY



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[To obtain more data on advertised products see page 536]

2,500,449 (Shell Development Co.)—Composition of matter containing glycidyl ethers and oxalic acid.

2,500,582 (Shell Development Co.)—Beta-aryloxy aldehydes.

2,500,599 (Shell Development Co.)—Catalytic hydroxylation of olefins.

2,500,600 (Shell Development Co.)—Compositions containing epoxyethers and diamines.

2,500,607 (Shell Development Co.)—Copolymers of diallyl phthalate with allyl vinyl phthalate.

2,500,780 (Standard Oil Development Co.)—Stabilization of low unsaturation isoolefinic copolymers.

2,500,822 (Socony-Vacuum Oil Co.)—N-Thenyl aldimine.

2,500,913 (Standard Oil Development Co.)—OXO synthesis followed by hydrogenation to alcohols.

2,500,983 (Standard Oil Development Co.)—Emulsion polymerization.

2,501,088 (Universal Oil Products Co.)—Oxidation of aromatic hydrocarbons in presence of nitro alkanes.

2,501,382 (Phillips Petroleum Co.)—Styrene and halogenated styrene.

2,501,600 (Socony-Vacuum Oil Co.)—Resinification of aromatic hydrocarbons with formaldehyde and clay.

2,501,610 (Shell Development Co.)—Diallyl-3,5-dimethylphthalate polymer.

2,501,692-3 (Phillips Petroleum Co.)—Emulsion polymerization in presence of diazo thioethers.

2,501,792 (Phillips Petroleum Co.)—Disulfide synthesis.

2,502,390 (Socony-Vacuum Oil Co.)—Wax-substituted polyalkylthiophene.

2,502,341 (Socony-Vacuum Oil Co.)—Stabilizing synthetic elastomers.

Lubricants

2,499,710 (Union Oil Co. of Calif.)—Anticorrosive lubricating oil.

2,499,723 (duPont)—Lubricant containing copolymers of ethylene and vinyl acetate.

2,499,983-4 (Rohm & Haas Co.)—Polyester lubricants.

2,499,997 (Sinclair Refining Co.) — Alkaline earth sulfonates.

2,500,085 (Sinclair Refining Co.)—Esters of unsaturated lower fatty acids.

2,500,159-60 (Socony-Vacuum Oil Co.)—High VI synthetic lubricants by heating olefin with synthesis gas.

2,500,161 (Socony-Vacuum Oil Co.)—High VI oils by reacting olefins with lead tetra-acetate.

2,500,162 (Socony-Vacuum Oil Co.)—Viscous oils by reacting long chain olefin with short chain.

2,500,163-4 & 7 & 247 (Socony-Vacuum Oil Co.)—Viscous oils by reacting olefins in presence of paraffin.

2,500,166 (Socony-Vacuum Oil Co.)—Viscous oil by heating monoolefin.

2,500,195 (Standard Oil Development Co.)—Metal xanthate derivatives.

2,500,202 (Socony-Vacuum Oil Co.)—Viscous oil by reacting monoolefin and vinyl aromatic.

2,500,244 (Socony-Vacuum Oil Co.)—Viscous oil by polymerizing alpha olefin in presence of cyclic hydrocarbon.

2,500,488 (Socony-Vacuum Oil Co.)—Lubricant containing phosphite and thiophene.

2,500,672 (Socony-Vacuum Oil Co.)—Viscous oil by polymerizing octene with styrene in presence of butyl thiol.

2,500,762 (Standard Oil Development Co.)—Condensed pour inhibitor.

2,501,731-2 (Union Oil Co. of California)—Sulfonate-bearing lube oil.

2,501,891-2 (California Research Corp.)—Phenate compounded lube oils.

Hydrocarbon Synthesis

2,499,372 (Koppers Co.)—Hydrocarbon synthesis.

2,500,331 (Standard Oil Co.—Indiana)—Finely divided iron catalyst.

2,500,516 (Standard Oil Co.—Indiana)—Hydrocarbon synthesis.

2,500,519 (Phillips Petroleum Co.)—Apparatus for hydrocarbon synthesis.

2,501,115 (Standard Oil Co.—Indiana)—Separation of hydrocarbon synthesis products.

2,501,695 (The Texas Co.)—Catalytic hydrocarbon synthesis.

Specialties

2,500,533 (Phillips Petroleum Co.)—Wax from synthesis gas.

2,501,770 (Standard Oil Development Co.)—Making water soluble materials water repellent with silicon halide.

2,502,366 (Socony-Vacuum Oil Co.)—Insecticide base oil toleramts.

2,502,392 (Hooker Electrochemical Co.)—Hydraulic fluid freezing below —37° F. comprising hexachlorobutadiene and isopropyl trichlorobenzene.

Catalysts

2,499,675 (Phillips Petroleum Co.)—Pelleted chromia-alumina catalyst.

2,499,680 (Socony-Vacuum Oil Co.)—Spheroidal gel desiccant.

2,500,146 (Union Oil Co. of California)—Bauxite-heavy metal oxide conversion catalyst.

2,500,197 (USA)—Conversion catalyst (silicate).

2,500,776 (Sinclair Refining Co.)—Reactivating reduced metal oxide catalysts.

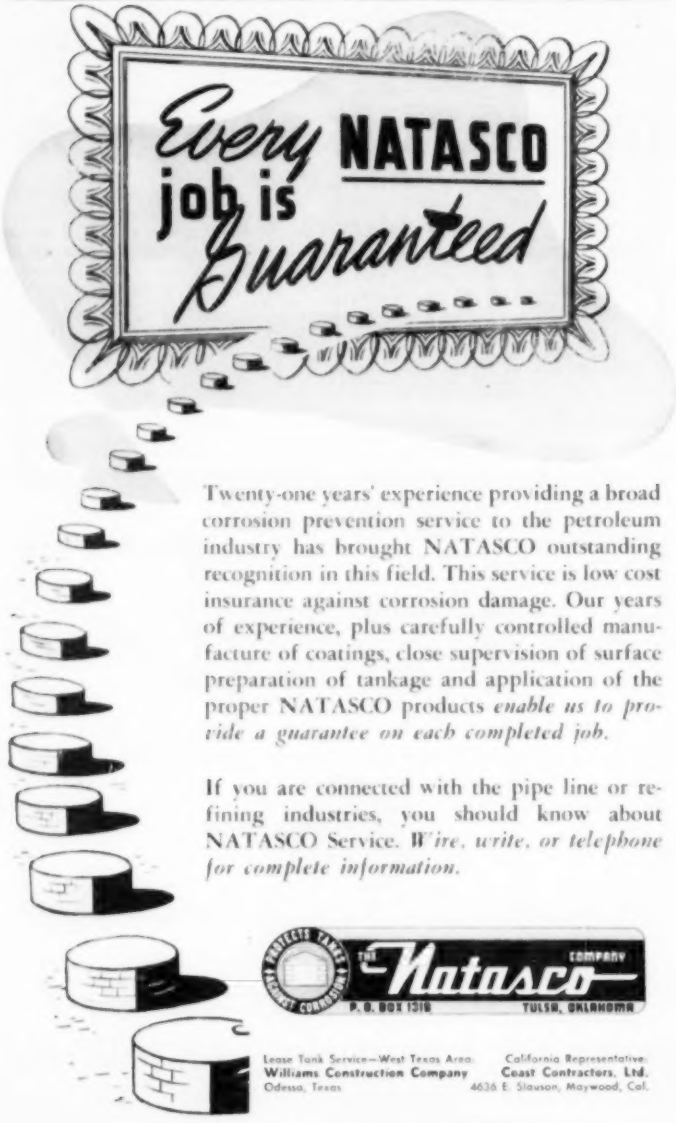
2,500,801 (Phillips Petroleum Co.)—Porous siliceous pebbles as catalysts.

Miscellaneous

2,500,585 (Bendix Aviation Corp.)—Distance per unit of fuel measure indicator.

How to Obtain Patents

Readers may obtain copies of any U. S. patent from the Patent Office at 25 cents each. Order by patent number direct from the Commissioner of Patents, Washington 25, D. C.



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Cracking Unit Yield Is Raised By Improved Vapor Removal

IMPROVED YIELD of cracked hydrocarbons from moving catalyst bed and pebble heater type installations can be obtained by redesigning the vapor removal section of such equipment, it is claimed. A recent invention, illustrated in Fig. 1, is said to accomplish this result.

Normally, catalyst or pebbles are introduced through the center conduit 35, and reaction gases pass off through a single conduit off center. It is necessary that an appreciable vapor space or cushion be maintained above the catalyst or pebble bed. This vapor space is necessary to prevent channeling of vapors through the top side of the bed closest to the outlet.

The gases leaving the top of the bed are at their hottest temperature. The surge volume of this vapor space is sufficient to keep the cracked vapors at high temperature for 0.02 to 0.10 sec. There is still additional surge volume in the outlet ducts leading across the top of the heater to a downcomer leading to conventional quench systems where the vapors are usually cooled by water or oil sprays to 100 to 150° F. At 1600 to 1900° F., the cracking rates of various hydrocarbon reactions are such that high losses of yield occur through secondary reactions.

In the improved reactor shown in Fig. 1, vapor space 27 is considerably smaller than is conventional. A series of outlets 28 in the top lead into refractory elbows 29 which are pierced by atomizing nozzles 31, positioned to throw jets of fluid through Venturi tubes 32. By placing these outlets 31 at locations so that each takes a proportionate share of the vapors from the bed, the deviation of vapor velocities from a given predetermined average will be so decreased that the need for a deep vapor pocket above the bed will be substantially eliminated. By materially reducing this retention time in the top of the heater, the yield of various olefins and acetylenes will be increased.

The use of the high velocity ejectors permit the reduction of final vapor pressure of cracked products above the bed and also provide for increased yield of olefins and acetylenes at lower pressures. Water has been found to be the most effective aspirating fluid because of its cooling effects. Commercial water-fog nozzles produce the desired effects and can be used to advantage. The water should be superheated.

U. S. 2,500,870, issued March 14, 1950, to Sam P. Robinson, assignor to Phillips Petroleum Co., Bartlesville, Okla.

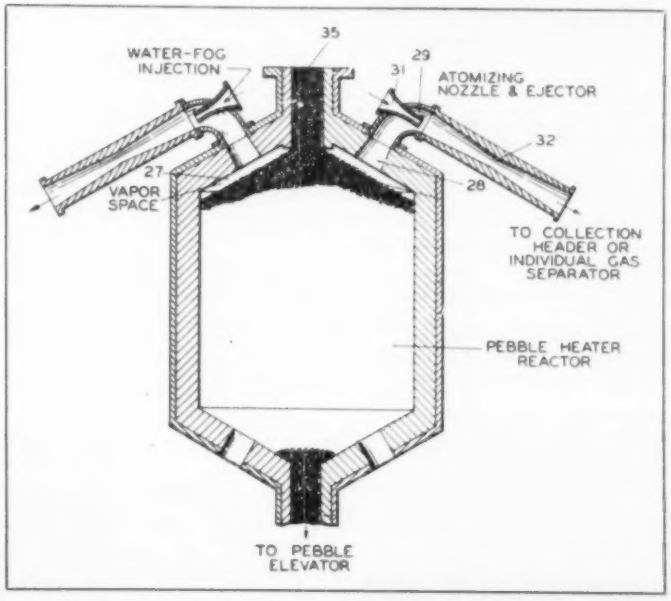


Fig. 1—Improved vapor removal outlets 28 increase yield of cracked products (U. S. 2,500,870)

Line Pulse Dampener Uses Cooling Coil and Seal Liquid

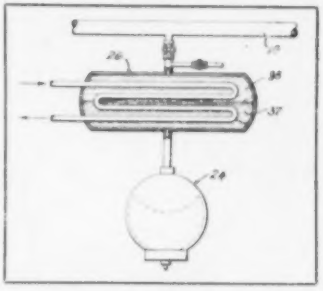


Fig. 2—One form of pulsation dampener useful for handling hot, corrosive fluids (U. S. 2,501,804)

A PULSATION DAMPENER has been designed for use on fluid streams at high temperatures, which might subject the dampening device to injury by overheating. In addition, provision has been made for protection against attack by corrosive fluids.

One form of the invention is illustrated in Fig. 2. The dampener 24 consists of a spherical vessel containing a bladder-like diaphragm capable on full distention of conforming to the shape of the spherical shell, but under normal operating conditions, assuming a deflected condition approximately as shown. Damaging effects of hot fluids in the main line 10 are reduced by means of the cooling condenser 26. This cooler may be made in other forms if preferred; for example, an air-cooled, finned pipe. If the line fluid 38 is corrosive, it can be kept separated from the dampening diaphragm by use of sealing liquid 37.

U. S. 2,501,804, issued March 28, 1950, to Cecil F. Yates and Claude B. Nolte, assignors to The Fluor Corp., Los Angeles, Calif.

Patents Issued in March

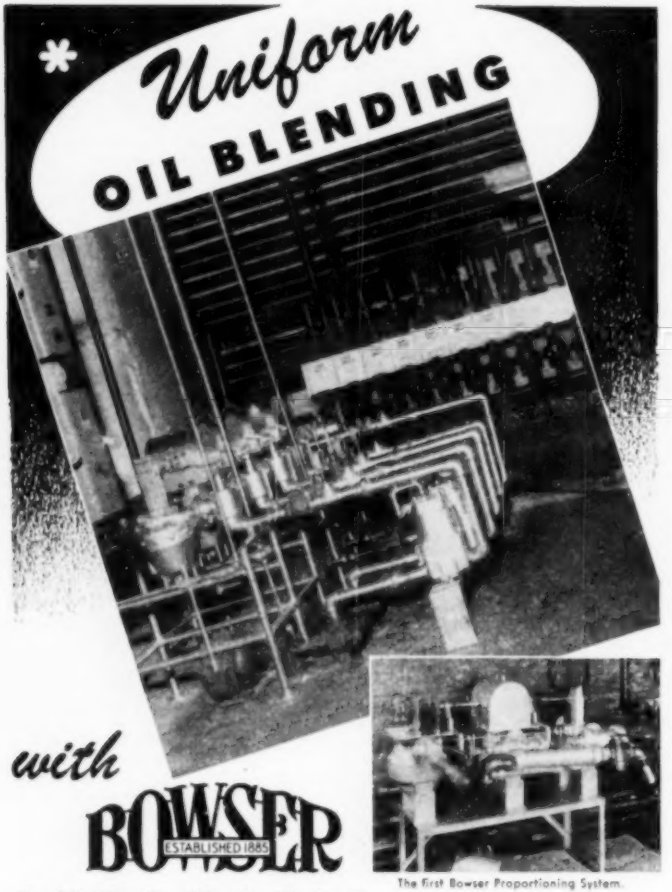
Processing, general

2,499,703 (Socony-Vacuum Oil Co., Inc.)—Heater for thermal cracking with granular solids.

2,500,056 (Std. Oil Development Co.)—Apparatus and method for solvent-cleaning finely divided solids.

2,500,240 (Gulf Research & Development Co.)—Apparatus for the separation of gaseous mixtures.

2,500,519 (Phillips Petroleum Co.)—Apparatus and process for the synthesis of hydrocarbons.



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LIQUID CONTROL SPECIALISTS SINCE 1885

Equipment Patent Review

2,500,774 (Worthington Pump and Machinery Corp.)—Water treating apparatus and method.
2,500,870 (Phillips Petroleum Co.)—Hydrocarbon cracking process and method using pebble heater with jet ejector.
2,500,114 (Phillips Petroleum Co.)—Fractionating apparatus.

Pumps

2,499,456 (Fairbanks, Morse & Co.)—Bearing sleeve for pump shafts.
2,499,614 (Homer E. Thornhill)—Valve cover for pump poppet valves.
2,500,227 (Nash Engrg. Co.)—Liquid pumping unit combining self-priming centrifugal with rotary positive displacement design.
2,502,334 (Frederick C. Melchior)—Valveless reciprocating pump of rotary, multi-cylinder design.

Tools

2,499,609 (John A. Riordan)—Quick-acting adjustable end wrench.
2,499,644 (Victor H. Heyn)—Quick adjusting end wrench.
2,500,238 (Elliott Co.)—Rotary expansible descaler for boiler tubes and the like.
2,500,461 (Aldo Lazzarini)—Claw-lever-and-rack-actuated parallel jaw wrench.
2,500,462 (Aldo Lazzarini)—Lever and gear sector operated locking parallel jaw wrench.
2,500,500 (B.M.C. Mfg. Corp.)—Toggle actuated and adjustably mounted, pivoted jaw wrench.
2,500,980 (Crutcher - Rolfs-Cummings Co.)—Pipe-bending machine.
2,501,000 (Leonard A. Parks)—Valve grinding tool.
2,501,893 (Joseph F. Francis)—Pipe beveling machine.
2,502,407 (William Gordon)—Quick-acting slidable jaw wrench.

Valves and Fittings

2,499,380, 1, 2, and 3 (Leland S. Hamer)—Gate valve and line blind combinations.
2,499,415 (Gordon C. Ralls)—Gate valve and line blind combination.
2,499,527 (Black, Sivalls & Bryson, Inc.)—Automatic control valve for storage tank systems.
2,501,328 (Albert G. Gurries)—Valve unit for hydraulic pressure systems.
2,501,635 (Crane Co.)—Rotary plug valve.
2,501,945—6 (The Duriron Co., Inc.)—Plug cock valves.
2,502,351 (Standard Oil Co.—Ohio)—Pipe coupling.

Heat Exchangers

2,499,284 (Air Preheater Corp.)—Multifluid manifold for heat exchange among three or more streams of fluid.
2,499,901 (Brown Fintube Co.)—Fin tube assembly.
2,501,795 (The Fluor Corp.)—Heat transfer equipment.

Instruments

2,499,674 (Emil Olson)—Hydrostatic liquid levelometer.
2,499,953 (The Texas Co.)—Linear integration meter.
2,500,410 (John C. Hewitt, Jr.)—Instrument float.
2,500,411 (John C. Hewitt, Jr.)—Instrument float control.
2,500,443 (Jerguson Gage & Valve Co.)—Differential pressure indicator.
2,500,935 (Jules Dietz)—Chart analyzer.
2,500,964 (Miles V. Sullivan and John K. Wolfe)—Apparatus and method for testing the inflammability of fluids.
2,500,997 (Phillips Petroleum Co.)—Electrical computing device.
2,501,604 (Minneapolis - Honeywell Regulator Co.)—Recorder with a single marker for making a pair of distinguishable records.
2,501,705 (Cornelius T. Beggs)—Apparatus for measuring liquid flow.
2,501,790 (Stanolind Oil & Gas Co.)—Photoelectric spark recorder.
2,501,791 (Stanolind Oil & Gas Co.)—Inkless recorder.

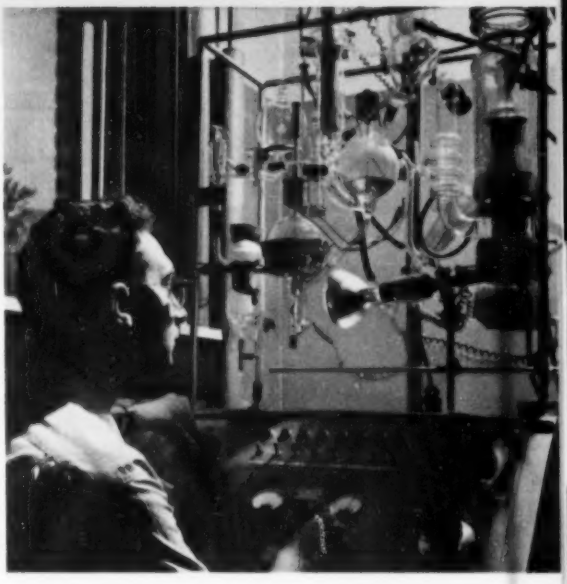
Silencers and Mufflers

2,500,551 (Edward A. Klewer, Sr.)—Muffler with expansion chamber and transverse perforated baffles.
2,501,753 (The Fluor Corp.)—Pulsation and flow control system for gas lines.
2,501,767 (The Fluor Corp.)—Muffler with internal side branch chamber.
2,501,794 (The Fluor Corp.)—Silencer with elongated pipe connecting plural chambers.
2,501,804 (The Fluor Corp.)—High temperature liquid pulsation dampener.

Du Pont Research { Functions In Two Ways

Research on Fuel Performance in Engines Available Today

The final measure of any fuel's performance is its behavior under actual driving conditions. That is why Du Pont maintains two road test fleets. One, a passenger car fleet, is located in the East; the other, made up of heavy duty trucks, is based at El Monte, California. To relate the findings from these operations with future developments, Du Pont also operates cars with experimental high compression engines, some of which utilize compression ratios as high as twelve to one.



Basic Long Range Research on Fuels of the Future

Just as engine design and characteristics change to give better performance, fuels likewise must be changed to meet new demands. To anticipate these changes, Du Pont is studying the basic nature of combustion, both from a physical and a chemical standpoint. The work is directed not only toward improvement of present antiknock compounds and other additives, but also toward the development of new compounds which will help refiners meet the higher performance standards of the future.

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The results of Du Pont research on fuels, fuel utilization, and fuel blending problems are available to all refiners. Some of these findings are in the form of published papers. Other information which may apply directly to problems that confront you can be obtained from Du Pont Sales or Technical Representatives.

Organized Attack on Industry-Wide Problems . . .

Many problems, such as sulfur-tetraethyl lead interaction in motor fuels, are common throughout the industry. Du Pont is aware of such problems and has launched a concerted attack upon them through all phases of research. In many instances this involves physical and chemical studies of fuels and combustion processes.

Facilities to Work on Your Problems . . .

The center of Du Pont Petroleum Chemicals Research is located at Deepwater, N. J. Here extensive facilities exist for research on problems involving fuels, their components, or their use in internal combustion engines. In addition to these studies, requirements for the future are constantly being explored in the Company's Wilmington Experimental Station, for which a new $30,000,000 expansion project is nearing completion.

Material on TEL and Additives

. . . A number of papers recording the results of Du Pont Research on various problems have already been published. Among these, the following may be obtained through your Du Pont Representative or the nearest Du Pont District Office:

- **Sulfur-Tetraethyl Lead Interaction in Motor Fuels** —*By* H. K. LIVINGSTON
- **Effect of Sulfur on Combustion of Leaded Gasoline** —*By* H. K. LIVINGSTON, J. L. HYDE, M. H. CAMPELL
- **Inhibition of Deterioration of Cracked Gasoline During Storage**—*By* C. J. PEDERSEN
- **The Effect of Sulfur Compounds on Octane Number of Leaded Fuels**—

  Part I—Comparison of Different Sulfur Compounds

  Part II—Sulfur Antagonism in Different Fuels

  By H. K. LIVINGSTON

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A-507

Gasoline and Cycling Plant Operation

Conducted by DAVE THORNTON

Answers to the questions presented regularly here are supplied through the co-operation of authorities with the equipment and engineering companies of the Natural Gasoline Supply Men's Assn., among others. Readers are invited to submit queries on plant problems in their own work.

Effects, Processing Economics Of Reforming Natural Gasoline

What is the effect of platforming on the octane rating and lead response of (a) a stabilized natural gasoline and (b) the motor fuel produced by cycling plants? What is the suggested minimum size of a Platforming unit?

Parts (a) and (b) of the first question can be answered as though they were one if we may be allowed a short preliminary explanation.

The optimum boiling range of a natural gasoline, cycling plant motor fuel, or straight run gasoline which can be improved by the Platforming process ranges from pentane to 400° F. endpoint.

The iso- and normal-butane which are contained in any of these fuels already are very high octane products and little is gained by passing butanes through the reactor, though there is some tendency to produce more iso-butane by isomerization. As is well known, the increase in vapor pressure does not make this a very profitable operation.

The same situation exists for the pentane fraction, only to a lesser extent, and it is normally not profitable to process the pentane fraction.

In view of this, Platforming charge is usually the C_5 to 400° F. endpoint boiling range material. In this boiling range, the material which we have processed varies more with the location of the field from which it was recovered than it does with the method of extracting from the gas. Natural gasoline differs from straight run gasoline principally in that there is a greater quantity of material boiling below 212° F. Mainly because of this fact, natural gasoline usually has a higher original octane rating than the average straight run. This, of course, means that, to reach a given octane level, the proportion of the natural gasoline which must be improved by Platforming is considerably less.

In order to illustrate this point, a natural gasoline was separated into various cuts which were Platformed. To make an 89 Research octane number with 3 cc. of TEL on the overall gasoline, it was only necessary to Platform about 28% of the material, blend the resulting product with the unprocessed lower boiling fraction and make-up to vapor pressure with butane. These results are shown in Table 1. The overall plant picture shows that the octane

TABLE 1—Platforming a Portion of a Natural Gasoline and Blending

Yield Basis: Liq. Vol. % of 10-Pound R.V.P. Natural Gasoline of 400° F. End Point

	10-Pound R.V.P. Natural Gasoline			Platformate	10-Pound R.V.P. Gasoline Blend
	Total	Light Gasoline	Reactor Feed	Total C_5-E.P.	Butane Plus Light Gasoline Plus Total C_5-E.P. Platformate
Yields on Platforming and Blending, L.V. %					
Butane	6.9				3.3
Light Gasoline (C_5 plus)	65.1				65.1
Reactor Charge	28.0			C_5-E.P.	28.1
Total	100.0			Platformate	26.1	94.5
Excess Butane					3.6
Total Liquid Product					98.1
Inspection Data					
°API	70.1	76.7	54.5	56.1	71.5
Octane Numbers					
Research Method (F-1)					
Clear	59.4	67.0	(18)	70.0	69.0
+3.0 ml. TEL/gal.	76.8	88.3	46	88.5	89.0
Motor Method (F-2)					
Clear	50.7	66.0	(18)	66.5	67.5
+3.0 ml. TEL/gal.	76.3	86.5	47	84.5	87.0

TABLE 2—Typical Results from Platforming Natural Gasoline

Platformer Feed Source	Lake Creek (Texas)			Haynesville Field (La.)			La Gloria (Texas)				Carthage (Texas)		
	Feed	Platformate		Feed	Platformate		Feed	Platformate			Feed	Platformate	
Yield, L.V. % of Platformer Feed	100.0	95.7	92.5	100.0	91.2	86.*	100.0	94.8	89.3	85.9	100.0	94.1	91.5
Inspections													
°API at 60° F.	57.3	55.5	54.1	58.7	60.4	60.5	51.8	51.6	53.1	55.2	59.5	62.2	63.2
Reid Vapor Pressure	2.8	4.7	8.6	(1.5)	8.5	10.5		4.0	8.5	13.3		9.8	13.2
K-factor	11.83			12.13			11.80				12.11		
Molecular Weight	104			120			123				115		
Sulfur, Wt. %				0.013			0.02						
ASTM D-86 Distillation													
I.B.P., ° F.	147	132	114	196	100	90	277	115	100	90	198	98	90
5%	174	158	137	214	127	112	284	198	130	110	210	125	120
10	182	170	152	220	143	128	286	242	150	135	215	140	130
30	206	198	186	248	198	180	290	282	223	190	232	182	170
50	234	226	218	278	238	226	294	294	275	248	258	218	205
70	273	264	256	311	276	270	300	304	300	290	294	258	245
90	336	324	316	352	335	337	313	325	326	325	348	325	318
95	368	356	343	368	362	368	320	337	340	340	369	352	342
E.P.	397	400	427	388	400	416	342	365	392	402	388	410	420
% Bottoms	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
% Loss	0.5	0.5	1.0	0.0	1.5	2.0	0.0	0.5	1.0	1.5	0.0	1.0	1.5
Octane Numbers													
Research Method (F-1)													
Clear	59.4	78.1	88.0	39.9	76.7	84.9	43.5	74.0	89.4	96.2	36.6	78.3	86.7
+3.0 ml. TEL/gal.	78.3	91.0	96.1	64.4	99.3	95.0	65.5	88.8	97.6	iso-C_5-0.1	62.0	91.9	96.0
Motor Method (F-2)													
Clear	53.7	72.3	80.2	35.1	73.0	78.8	...	68.1	80.9	86.3	33.9	73.7	80.3
+3.0 ml. TEL/gal.	76.6	(85.0)	(88.0)	64.2	(87.0)	(90.7)	...	82.0	88.1	93.4	63.5	86.7	90.0

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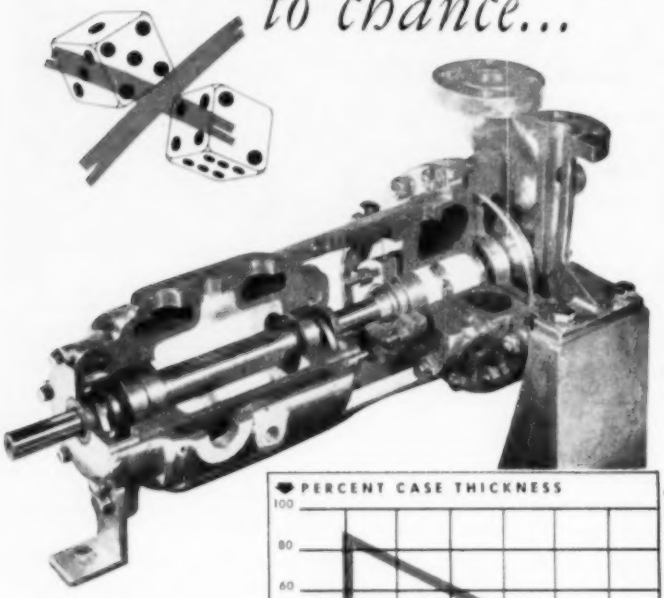

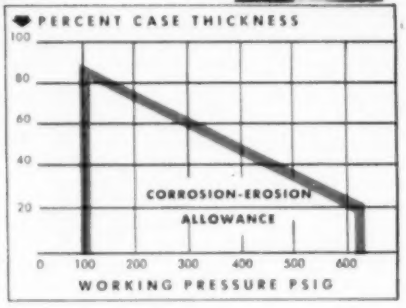

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PR 11

level was attained and only a relatively small amount of butane was in excess of that required for the original natural gasoline.

Included in Table 2 are inspections on a number of natural gasolines which have been Platformed. These are for the most part the higher boiling fractions. While detailed data on the lower boiling fraction is not available, this will range approximately 90-92 leaded Research octane numbers. The lead response for 3 cc. of TEL varies from 14-15 numbers at present premium gasoline octane number levels to 9-10 at 95 leaded Research octane number.

Minimum Practical Size

The minimum practical size of a Platforming unit depends on economic considerations and not on mechanical or process limitations, as minimum equipment sizes and operating control are not in any degree effected by size. As is usual with most plants, the per barrel cost increases with decreasing size.

The design of natural gasoline plants is, of course, quite varied but it appears that Platforming units can be incorporated into most natural gasoline plants with little difficulty.

Many of these plants already have facilities available which can take over the duties of feed preparation and product stabilization. The net gas can be returned to the absorption system for butane and propane recovery. It therefore appears that little additional fractionation equipment need be acquired to install a Platforming unit. The new equipment necessary will include that contained in the reactor section. This includes the heaters, reactors, heat exchangers and compressor. The reactor section represents only about 60% of the cost of the total unit, due chiefly to the fact that no catalyst regeneration equipment is required.

Approximate costs for a complete new Platforming unit including all new equipment are: $500,000 for a unit having a reactor charge of 1000 b/d and $700,000 for a 1500 b/d unit. A 500 b/d unit would cost approximately $350,000.

Operating costs, including labor, utilities, maintenance, taxes and insurance, catalyst, and royalty will vary from 30c to 37c per barrel of reactor charge for a 1500 b/d unit.

The minimum practical size for a Platforming unit depends primarily on local conditions. However, if the case in Table 1 is used for 500 b/d or reactor charge or a total of 1785 b/d of 10 lb. RVP natural gasoline, the results indicate a very satisfactory return.

The product prices used were butane at 3c per gal. and the price of

Questions and Answers

10 lb. RVP natural gasoline at levels of 2c and 3c per gal. below regular grade gasoline. Operating costs for a 500 b/d unit would be approximately 50c per bbl. The pay-out time on the above basis ranges from seven months at 3c differential to one year at 2c.

The price for platformed gasoline was assumed to be that of regular grade gasoline. It will be evident from the data in Table 1 that this assumption is entirely warranted and, in fact, very conservative.—R. E. Sutherland and D. D. Hansen, Universal Oil Products Co., Chicago.

(NOTE: For further details regarding the Platforming process, equipment required and the effect (on refinery gasoline), the reader is referred to PETROLEUM PROCESSING for April, 1950: "Platforming—Operating and Design Details," by W. F. Bland, pp. 351-55; and "Platforming—Chemical Reactions, Operating Variables, Product Properties," by V. Haensel, pp. 356-60.—D. T.)

MEETINGS . . . for the Oil Man

MAY

10-14, Houston Industrial Exposition, 1st Annual Meeting, Coliseum, Houston.

15-18, National Fire Protection Assn., Annual Meeting, Haddon Hall, Atlantic City.

15-18, American Petroleum Institute, Central Committees on Accident Prevention and Fire Protection, Mid-Year Meeting, Haddon Hall, Atlantic City.

22-24 American Gas Assn., Production and Chemical Conference, Hotel New Yorker, New York.

28-31, American Institute of Chemical Engineers, Regional Meeting, New Ocean House, Swampscott, Mass.

JUNE

4-9, Society of Automotive Engineers, Summer Meeting, French Lick Springs Hotel, French Lick, Ind.

8, Chemical Market Research Assn., Annual Meeting, Hote. Roosevelt, New York.

8-10, National Society of Professional Engineers, Annual Meeting, Hotel Statler, Boston.

12-16, American Society of Mechanical Engineers, Oil and Gas Power Division Conference and Exhibit, Lord Baltimore Hotel, Baltimore.

12-16, American Institute of Electrical Engineers, Summer and Pacific General Meeting, Huntington Hotel, Pasadena.

15-16, Pennsylvania Grade Crude Oil Assn., Annual Meeting, Hotel William Penn, Pittsburgh.

16-17, American Chemical Society, Division of Analytical Chemistry, Third Annual Summer Symposium, Ohio State University, Columbus.

19-22, Chemical Institute of Canada, Annual Meeting, Royal York Hotel, Toronto, Ont.

19-23, American Society of Mechanical Engineers, Semi-Annual Meeting, Hotel Statler, St. Louis.

19-23, Manufacturing Chemists Assn., Annual Meeting, Hotel Monmouth, Spring Lake, N. J.

26-30, American Society for Testing Materials, 53rd Annual Meeting, 9th Exhibit of Testing Apparatus and Related Equipment, Chalfonte-Haddon Hall, Atlantic City.

JULY

3-7, The Institute of Petroleum, Second Oil Shale and Cannel Conference, Glasgow, Scotland.

10-14, Society of Chemical Industry, Sixty-Ninth Annual Meeting, Newcastle-on-the-Tyne, England.

AUGUST

14-16, Third Western Packaging Exposition, Civic Auditorium, San Francisco.

14-16, Society of Automotive Engineers, West Coast Meeting, Biltmore Hotel, Los Angeles.

WeldOlets, Butt Welding — Available as standard, with outlet sizes from ⅛" to 24", both straight and reducing for use with Schedule 40 pipe up to 12" outlet. Outlet sizes 12" - 24" for standard weight pipe (⅜" wall). Also available for Schedule 80 services through 8" outlet and extra strong through 24" outlet size (for use with pipe having ½" wall).

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With WeldOlet branch pipe welding fittings you provide the quickest, most economical, most satisfactory method of obtaining full pipe strength at branch connections.

Note in the above illustration how the WeldOlet tapers to provide a single bevel groove joint at the crotch section and blends into a V-butt joint at the ear portion.

WeldOlets need no additional reinforcement to establish and fully maintain original strength on ASTM A-106 Seamless Steel Grade A Pipe, as set forth in Code for Pressure Piping, American Standards Association, B31.1-1942, and Supp. No. 2, B31.1-b-1947.

To meet special conditions, these fittings can be furnished in any forgeable metal including wrought iron, toncan iron, nickel, Monel, Everdur, stainless grades 304, 316, 347, etc.

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WeldOlets, Socket Welding — Available as standard, with outlet sizes ⅛" - 10", both straight and reducing, for use with Schedule 40 pipe. Also available in Schedules 80 and 160 up through 4" outlet size.

ThredOlets — Available as standard, with outlet sizes ⅛" - 10", both straight and reducing, for use with Schedule 40 pipe. Also available in Schedule 80 up through 2" outlet size.

Fig. 1 — Cut-away view of reducing size WeldOlet with welding outlet in place. The external rib and wide bases or footings of WeldOlets eliminate the need for extra supports to take care of bending or vibrational stresses at crotch section, the point of greatest stress.

Fig. 2 — Note blending of ear portion of welding fitting to run pipe. Extension of weld metal below inside scarfed portion of pipe insures all sections of joint greater than pipe wall thickness.

Economic Analyses

Process Design

Knowledge of Corrosion Problems

Mechanical Design

Controls and Instrumentation

Scheduling

Estimating

Drafting

Procurement

Inspection

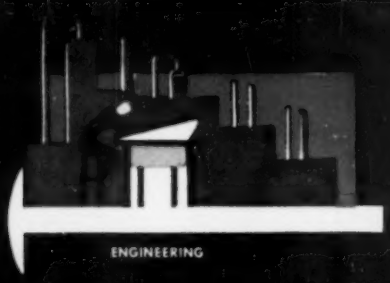
Expediting

Field Construction

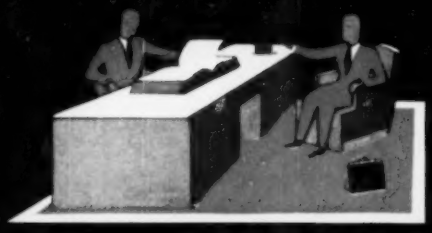
Labor Relations

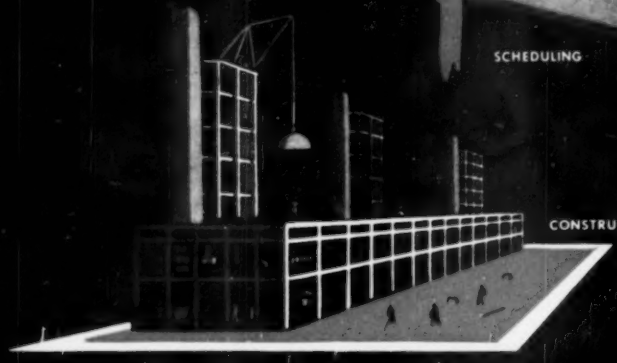
Initial Plant Operation

Intimate Knowledge of Latest Technical Developments



FROM THE





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NEWS OF

Manufacturers—Suppliers—Engineering Firms

Serving the Petroleum Processing Industry

Chiksan Opens Warehouse in East

In order to expand customer service in the East and step up deliveries, Chiksan Co. of Brea, Calif., has established a warehouse stock in the Federal Storage Bldg., 155 Washington St., Newark 2, N. J. The eastern headquarters for Chiksan and the Chiksan Export Co. have been transferred from 50 Church St., New York 7, to the Newark address.

Considine Moves Up at Brown

Douglas M. Considine has been appointed manager of the market extension division, general sales, of Brown Instruments division of the Minneapolis-Honeywell Regulator Co. His new duties will include direction of advertising and technical and trade editorial activities. He will continue as technical editor of Brown's house-trade publication, *Instrumentation*, and will headquarter in the main offices in Philadelphia.

Dillon Buys Back from Climax

S. V. Dillon recently announced the re-purchase of the Dillon coupling from the Climax Division of General Finance Corp. Dillon, who is president of the Dillon Co., Tulsa, sold his interests to Climax during the war when materials were difficult to secure. This company manufactured the Dillon coupling, which has been marketed during the past few years under the name of the Climax Lock Coupling.

Mr. Dillon states the new warehouse owned by his company in Tulsa can give immediate delivery of the coupling in a wide range of sizes.

Underwriters' Lists Davis Product

Listing of the Davis Emergency Equipment Co. "Vapotester" by the Underwriters' Laboratories has been announced. The device, also approved by the Laboratories of the Associated Factory Mutual Fire Insurance Cos., is designed for the detection of combustible gases and vapors.

CNGA Man Promoted at Fluor

The promotion of Harold J. Bordelon to the post of advertising supervisor of The Fluor Corp. Ltd., has just been announced. He has been associated with the company for the past eight years and was formerly assistant advertising manager previously connected with *Fluor-o-Scope*, the company employe magazine. Active in business and civic affairs in the Los Angeles area, Mr. Bordelon has been publicity chairman of the California Natural Gasoline Association for the past two years.

Du Pont Petroleum Division Changes

A number of changes in personnel have been announced in the Petroleum Chemicals Division of E. I. du Pont de Nemours & Co. Joseph L. Stecher, formerly manager of petroleum chemicals production, has been appointed assistant sales director of the division. Emory M. Fanning, who was petroleum chemicals sales manager, has been named assistant sales director of Kinetic Chemicals, Inc., manufacturer of "Freon" fluori-

Mr. Stecher

Mr. Fanning

Mr. Simpson

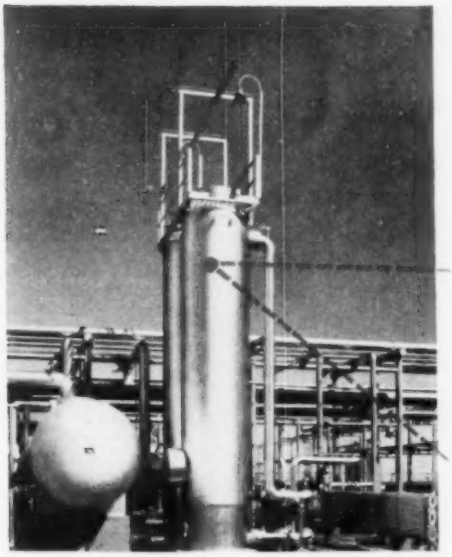
Mr. Conklin

Mr. Wirth

Mr. Towery

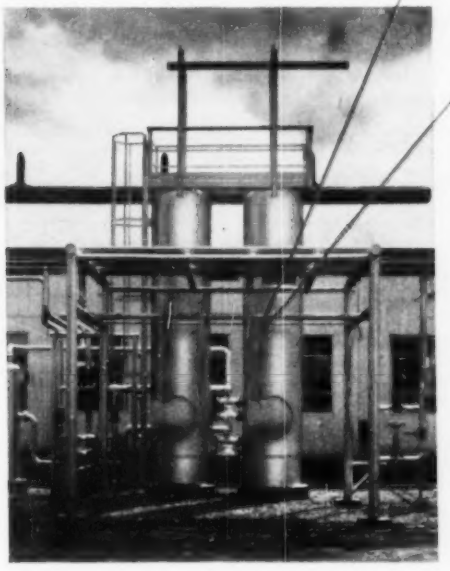
National Foam Moves General Offices to West Chester, Pa.

National Foam System, Inc., has moved its general offices from Philadelphia to the plant at West Chester, Pa., in order to consolidate activities at one address. The plant office building was altered to provide for the expanded staff, as well as the increased chemical laboratory and engineering department



LIQUID DEHYDRATION UNIT

Each tower is charged with 1590 lbs. of ALCOA *Activated* Alumina. Approximately 240,000 gallons of liquid hydrocarbons are dried daily to a dew point of minus 40° F. Liquid enters the towers at 90° F. and 390 psig. Reactivation on an 8-hour cycle with liquid hydrocarbons heated to 450° F.



AIR DEHYDRATION UNIT

Approximately 100,000 cubic feet of air entering the towers at 80° F. and 50 psig, are dried to *minus* 40° F. dew point daily. Each tower contains 5000 lbs. of ALCOA *Activated* Alumina. Air, heated to 450° F., regenerates the alumina on a 16-hour cycle.

both AIR and LIQUID dried to **minus 40° F.** with ALCOA Activated* Alumina

These drying units were designed for the Maysville, Oklahoma, unit of the Garvin County Plants, operated by Warren Petroleum Corporation for itself and four other owners. ALCOA *Activated* Alumina was selected as the desiccant to do the job because it dries *both* liquid and air quickly, efficiently and economically.

ALCOA *Activated* Alumina is a commercially pure, highly inert adsorbent that has high resistance to crushing, shock and abrasion. It does not soften, swell or disintegrate even when immersed in water. It can be reactivated an almost unlimited number of times with no appreciable effect on efficiency. This, coupled with its relatively low initial cost, makes ALCOA *Activated* Alumina a most economical drying agent.

Let us send you complete information on this reliable, versatile desiccant. Write to ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION, 616E Gulf Building, Pittsburgh 19, Pa.

*Reg. T. M., *Aluminum Company of America*

Alcoa Chemicals

ALCOA

ALUMINAS and FLUORIDES

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[*To obtain more data on advertised products see page* 536]

SHOPPING FOR BLOWERS?

Look at *R-C dual-ability* with its wide selection to suit almost any job

Asking Roots-Connersville about blowers, exhausters and gas pumps has been standard practice among buyers for almost a century. That's because building such equipment is the only job we do. We're outstanding specialists in handling gas and air.

You'll gain from our wide varieties of sizes, types and capacities from 5 cfm to 100,000 cfm. We're the only manufacturers offering you the *dual-choice* between Centrifugal and Rotary Positive designs—and that *dual-ability* is important when it comes to matching the units to the jobs to be done.

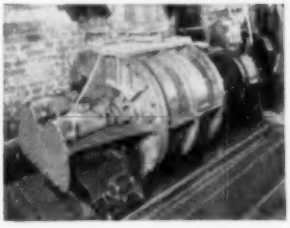
So—when shopping, be sure to call on Roots-Connersville, the specialists. When you're interested in vacuum pumps, meters or inert gas generators, we're equally well fitted to fill these needs, too.

ROOTS-CONNERSVILLE BLOWER CORPORATION
505 Texas Avenue, Connersville, Indiana

Type of Centrifugal Blower supplied to an oil company in Texas. Capacity, 13,000 cfm.

Rotary Positive Gas Pump, rated 1,500 cfm, installed in western refining company.

ROTARY



ROOTS-CONNERSVILLE

ONE OF THE DRESSER INDUSTRIES

News of Suppliers

nated compounds for the refrigeration, air-conditioning, and aerosol industries.

E. Hearn Simpson and David H. Conklin have been appointed sales managers of the petroleum chemicals division, Mr. Simpson to have charge of industrial sales, Mr. Conklin to direct sales promotion.

Charles Wirth, III, moves from Tulsa, where he was Mid-Continent District Manager, to New York City as Eastern District Manager. At Tulsa, he organized the office and Petroleum Service Laboratories during 1947. A graduate of Tulane with an MS degree in organic chemistry, he served with Gulf Oil Corp. and Universal Oil Products Co. prior to joining du Pont.

Charles D. Towery, service representative in the Gulf Coast District, has succeeded Mr. Wirth at Tulsa. A graduate of Texas A & M, he worked with Gulf, Pure Oil Co., and Bethlehem Supply Co. before coming with du Pont in 1947.

Western Supply Promotes Hughes

Mr. Hughes

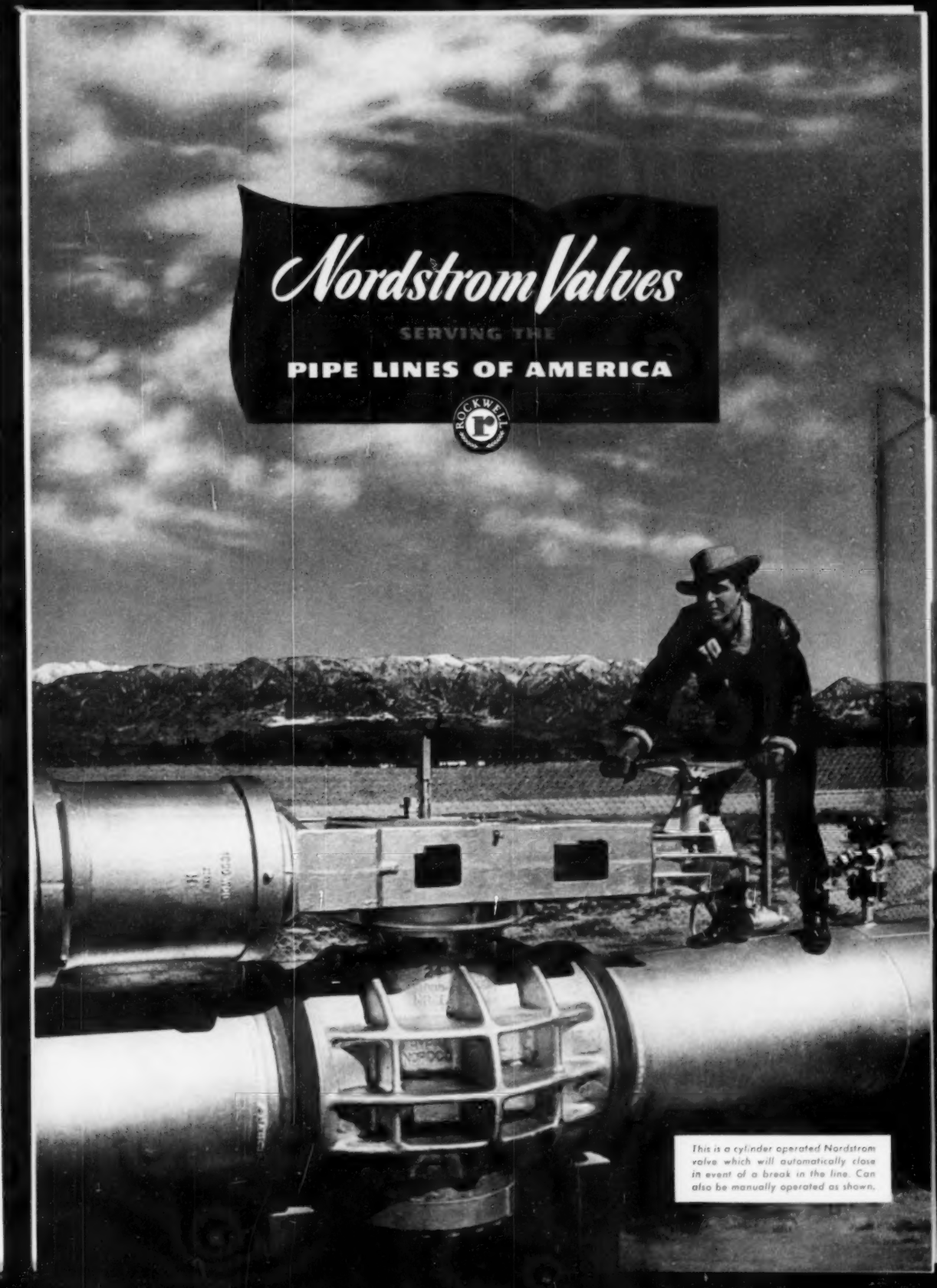
James E. Hughes, associated with Western Supply Co. of Tulsa since 1946 at which time he joined the firm to develop the Heat Exchanger Dept., has been elected vice president. Prior to joining Western, Mr. Hughes was associated with Phillips Petroleum Co. in the engineering department and in licensing Phillips' patent structure.

Western Supply, a member of the Tubular Exchanger Manufacturing Association, has expanded its coverage of heat transfer equipment to embrace all phases of petroleum processing and product, crude and natural gas transmission.

Ansul Shown in March of Time Film

A demonstration of a dry chemical fire extinguisher, similar to many now being used in petroleum refineries, will be seen in the new March of Time documentary film, "Where's the Fire?", to be released nationally in May and June.

The film will show a raging gasoline tank truck fire being put out in a matter of seconds with an Ansul Chemical Co.'s Model 30-B hand extinguisher. The March of Time film will trace the development of fire-fighting equipment from the early days of hand-pumped engines to the present.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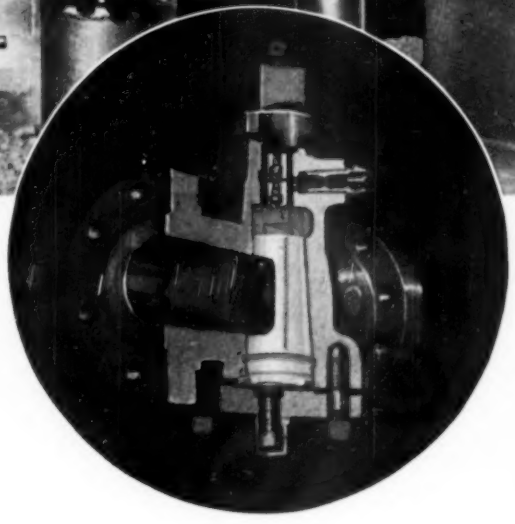
ROCKWELL
This is a cylinder operated Nordstrom valve which will automatically close in event of a break in the line. Can also be manually operated as shown.

GAS CONTROL engineered with foresight



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It's the *know how* of designing and making high pressure valves that counts. Given the toughest valve problems of virtually every industry, Nordstrom valve engineers have attained standards far beyond those normally set by industry. As examples: (1) pressures to 15,000-lb test; (2) temperatures to 1000° F.; (3) development of brittle-resistant alloys for sub-zero service; (4) Merchrome coating of more than file-hardness to resist corrosion and abrasion; (5) large size designs up to 54-inch; (6) a full line of lubricants; and (7) automatic lubrication by use of Hypermatic lubricant. Nordstrom leads the field.

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Book Reviews

Complete Revision, Expansion In Perry's New Third Edition

Chemical Engineers' Handbook, 3rd Edition, edited by John H. Perry; 7 x 10 in.; xvi + 1942 pages, fabrikoid binding, illustrated, indexed. $15.00. McGraw-Hill Book Co., 330 West 42nd St., New York 18, N. Y.

The new 3rd edition of Perry's well-known *Chemical Engineers' Handbook* represents a complete revision and considerable expansion over the previous edition, published in 1941.

In physical makeup itself, the new volume is a great improvement over earlier editions. For this reason alone, the publishers are deserving of a round of applause. The old, typical handbook size page—about 5 x 7 in.—has been discarded in favor of the full book size page of 7 x 10 in. This provides for far easier handling when the book is being used for reference or for study. The old handbook size page was perfectly in order when the total pages in a book were around 500. But in the case of the last edition of Perry's, where total pages exceeded 3000, the book size bordered on the ridiculous and was anything but easy to handle.

As a result of this change in format, the new volume has approximately one-third more space within its covers for the vast amount of information which was needed to bring it up to date. More importantly, the larger page size permits reproductions in larger sizes of pertinent graphs and illustrations, thus providing greater clarity and accuracy. All illustrations have been newly prepared.

The index merits special mention. It has been made as complete as possible by using not only the more common reference words but also their synonyms and equivalents.

Twenty of the major sections have been thoroughly revised. Nine others have been rewritten and expanded, and in addition, three important chapters have also been rewritten and expanded. Several new sections have been added to the edition: 1) General Theory of Diffusional Operations, 2) Furnaces and Kilns, 3) Size Enlargement, 4) Azeotropic Distillation, 5) Multi-component Distillation, 6) Extractive Distillation, 7) Molecular Distillation, and 8) Dialysis. Many of these are of course of direct interest and value to the petroleum processing engineer.

The following sections or chapters were deleted in order to use the space for material believed to be more valuable to the reader: Reports and Report Writing; Indicators, Qualitative Analysis, Organic Chemistry. The information on indicators, however, was revised and placed in other sections.

Editor Perry, associated with E. I. du Pont de Nemours & Co., was again assisted by a large staff of contributing and advisory editors, many of whom are new.

Mines Bureau Issues First In Series on Crude Fractions

Composition of Petroleum; Properties of Distillates to 600° F., Technical Paper 722, March, 1950. By W. C. Holliman, H. M. Smith, C. M. McKinney and C. R. Sponsler. Dept. of Interior, Bureau of Mines; 6 x 9 in., 55 pages, heavy paper binding. Supt. of Documents, U. S. Government Printing Office, Washington 25, D. C.; price 20c.

This is a comprehensive study of the distillates from 10 important U. S. Crudes, selected because of their widely varying characteristics. Part I is concerned with the development of design, construction and use of special distillation apparatus large enough to permit determination and comparison of many physical and chemical characteristics of the distillates and blends of distillate fractions, not ordinarily made in routine analyses by the Bureau.

Part II uses the laboratory data of Part I to develop and expand correlations, whereby Bureau routine analytical data may be used to determine the probable value of a crude oil as a source of products meeting particular specifications. Methods of approximating ASTM boiling range, sulfur content, viscosity, aromatic content and aniline points are described.

Included are data concerning the determined properties and computed functions of these crudes and their distillate fractions and blends. Comparison with Bureau routine analyses of the same crudes are made. Apparatus developed and methods of analysis and calculation are described.

1950 Appendix Is Published For ASTM Engine Manual

1950 *Appendix to ASTM Manual of Engine Test Methods for Rating Fuels*, 6 x 9 in., 32 pp., paper binding. $1.00. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Penna.

The 1950 *Appendix* to the ASTM's engine test methods manual, issued in January, includes changes through 1949 in the 1948 Manual. The following summary shows the material included in the 1950 Appendix and indicates those sections of the original knock test manual which have been revised:

Optional Use of Detonation Meter for Motor (D 357) and Research (D 908) Methods.

Table 1A—Micrometer Settings for Standard Knock Intensity at a Barometric Pressure of 29.92 in. Hg.—For Detonation Meter Only. For Use at Altitudes from Sea Level to 1600 ft., $\frac{5}{16}$ in. Venturi.

Table VA—Micrometer Settings for Standard Knock Intensity at a Barometric Pressure of 29.92 in. Hg.—For Detonation Meter Only. For Use at All Altitudes, $\frac{5}{16}$ in. Venturi.

Revised Reproducibility Sections for Motor (D 357), Research (D 908), Aviation (D 614), Supercharge (D 909), and Cetane (D 613) Methods.

Table XXIII—ASTM Conversion for Octane Numbers to Performance Numbers (covers Octane Nos. from 70 to 100).

Table XXIV—ASTM Conversion from Tetraethyl lead in Iso-octane to Performance Numbers (covers TEL content from 0 to 6 ml.).

Revisions in Aviation Method and in Supplements II and IV.

Proposed Carburetor Jacket for Use with Motor and Research Methods to Rate High Vapor Pressure Fuels.

Table XXV—List of Equipment Changes to January 1, 1950.

Table XXVI—Summary of Equipment and Conditions for ASTM Engine Test Methods. (This Table Supplements the Summary of Operating Conditions in Table XV of the 1948 Manual.)

Table XXVII—Recommended Torque Values for ASTM-CFR Engines.

Table XA—ASTM Octane Number Conversion for Blends of Standardization Fuel X-6 and n-Heptane.

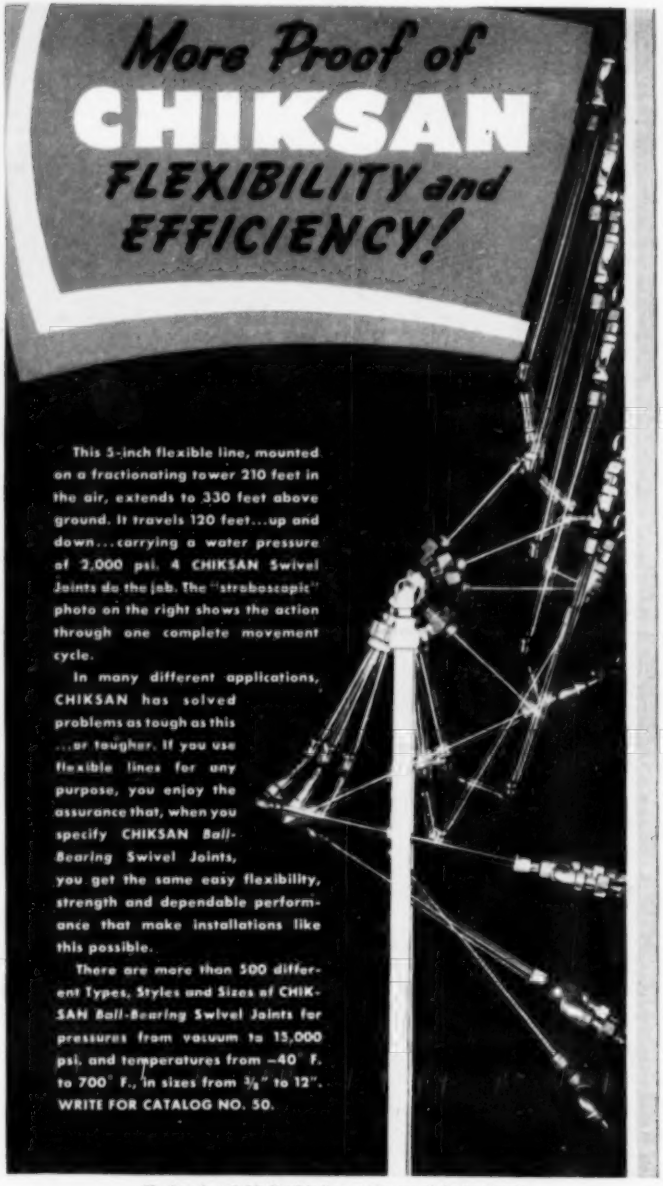
Errata and Editorial Changes in the 1948 Manual.

Guide Tables 1A and II, and VA and VI are available on 17 by 11 in. sheets, at 25c for each table. The 1948 Manual, including the new 1950 Appendix is available at $8.75. Order direct from the ASTM.

First Maintenance Conference Papers Available in New Book

Techniques of Plant Maintenance—1950; Part I, *Prepared Papers and Addresses*; Part II, *Questions and Answers*; 8½ x 11 in., 278 pps., illustrated, soft paper covers, staple binding, mimeographed. $2.00 for both volumes. Clapp & Poliak, Inc., 341 Madison Ave., New York 17, N. Y.

Techniques of Plant Maintenance—1950 represents the proceedings of the First Plant Maintenance Conference, held in January, 1950, in Cleveland. Part I comprises 15 papers and a symposium on preventive maintenance as influenced by proper lubrication. Included are 47 pages of tables, diagrams, illustrations, charts, and graphs. Subjects covered in the various papers include organization of maintenance and its relationship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to management, costs and budgeting of maintenance programs, and a number of specialized discussions on particular phases of an over-all maintenance program. Part II consists of 554 questions and answers which took place during the discussions on the floor following presentation of the papers.

A wealth of helpful information has been assembled in these two volumes. It is indeed unfortunate that the data is going to be extremely difficult to use. A carefully prepared index would have been invaluable as an aid to the reader. Also, it would seem that the questions and answers sections should have been placed following each paper to which they refer, rather than in a separate volume with no further reference except the authors' names. With the present arrangement, the reader will be put to considerable time to dig out such data as he may be interested in.

Government Publications

A Manometric Precision Procedure for Determining the Vapor Pressure of Aviation Gasolines, Report of Investigations 4635, January, 1950, by W. C. Holliman and M. G. Barker, Dept. of the Interior, Bureau of Mines; 8 x 10½ in., 17 pages, heavy paper binding.

Special Equipment in the Coal-Hydrogenation Demonstration Plant, Report of Investigations 4584, January, 1950, by J. A. Markovits, K. C. Braun, J. T. Donovan, and J. H. Sandaker, Dept. of the Interior, Bureau of Mines, 8 x 10½ in., 40 pages, heavy paper binding.

A Bureau of Mines Method for Determining Porosity: A List of Porosities of Oil Sands, Report of Investigations 4548, by Cleo Griffith Rall and D. B. Taliaferro; 8 x 10½ in., 28 pages, heavy paper binding.

Order copies of the above booklets from the Bureau of Mines, Publication Office, 4800 Forbes Street, Pittsburgh 13, Penna.

Asphalt from Rocky Mountain Crude Oils, Laboratory Preparation and Comparison, Technical Paper 717, by K. E. Stanfield and Rethel L. Hubbard, U. S. Dept. of the Interior, Bureau of Mines; 6 x 9 in., 77 pages, heavy paper binding, 25c ea. Order from Supt. of Documents, U. S. Govt. Printing Office, Washington 25, D. C.

Safe Handling of Radioactive Isotopes, Handbook H42; National Bureau of Standards, 29 pages, 15c. Order direct from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

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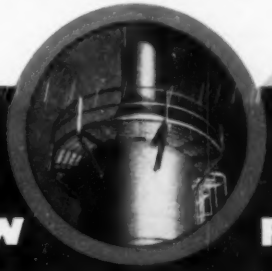

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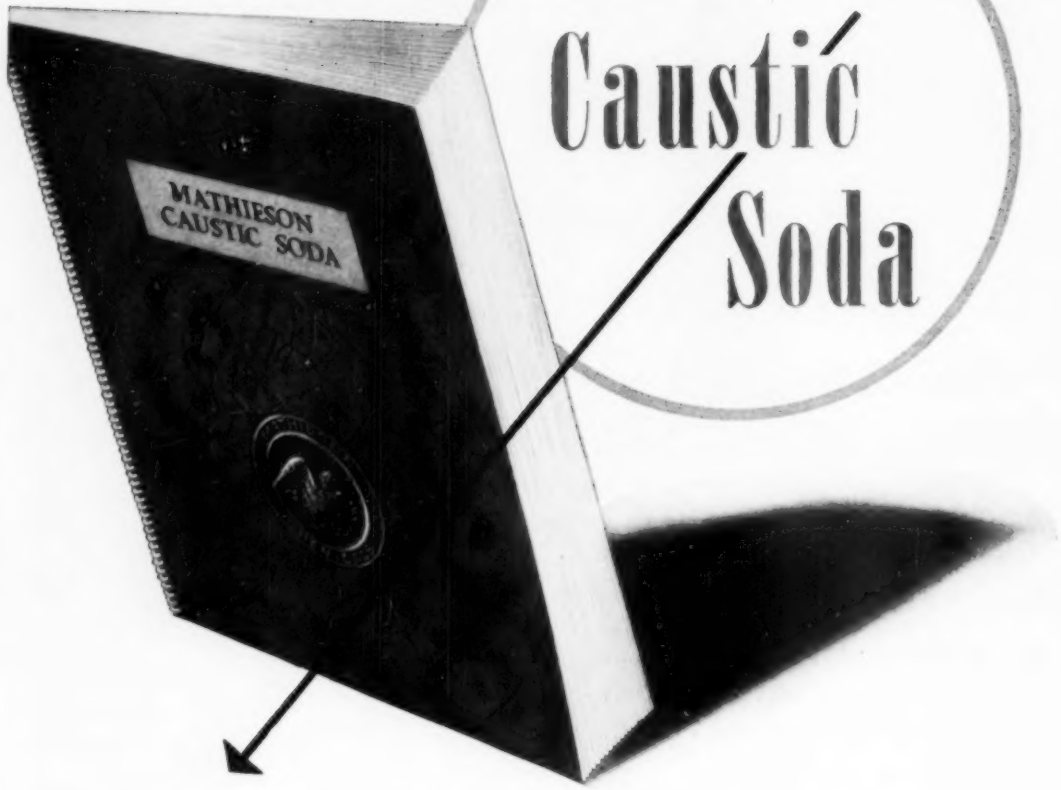

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REFINING TRENDS

Product Inventories At Refineries Are Reduced Through April

THE position of U. S. refineries as regards their inventories of refined products is greatly improved from a year ago. Runs to stills for the first quarter also were slightly less than for the first quarter of 1949, while demand for motor fuel, heating oils and residual fuels has been greater than a year ago. These same general trends continued through April, it is indicated. Because of heavy liquidation of stocks the Bureau of Mines sets probable crude runs to still in the second quarter at 5,370,000 b/d, as compared with the earlier forecast of 5,335,000 b/d.

On April 1, stocks of the four major products at refineries and main terminals were around 228,000,000 bbls., while on April 1, 1949, they were over 252,000,000 bbls. The larger amount of gasoline in storage this year was more than offset by the reductions in stocks of heating oils and residual fuels. Even more important, stocks have been further reduced in April by over 8,000,000 bbls.

In April, 1949, there was a net increase in refined product stocks of around 3,000,000 bbls. In April 1948, there was also a small net increase in refined products inventories.

Crude Runs—Total runs in April were reduced through strikes at individual refineries, the indicated rate of operations being about the same as in April, 1949. Total runs in May of 5,390,000 b/d are forecast. In the first quarter runs were about 1.7% less than in same period in 1949.

Table 1, which gives a breakdown of crude runs to stills for the first quarter by refining areas, shows the largest change to be in California, which ran 9.2% less crude in the current period than in the first quarter of 1949. For the U. S. except California it is indicated from the preliminary figures that the volume of runs was about on a par with 1949.

Motor Fuel—Indicated output in April is about in line with that of a year ago, while for the first quarter of 1950, indicated output is 2.7% larger than for 1949. The use of natural gas liquids in motor fuel was nearly 10% larger in the first quarter of 1950. Indicated motor fuel demand for the first quarter is 4.5% larger than a year ago.

Gasoline stocks as of late in April were about the same in terms of day's supply as of the end of April, 1949. Table 2 shows the location of gasoline stocks on April 1 by refining areas, as compared with April 1, 1949. Total U. S. stocks were 6.4% larger than on April 1, 1949. However, excluding California where stocks were 28% greater this year, gasoline inventories for the rest of the U. S. were only 3.3% larger.

Heating Oils—Indicated production in April was well above a normal seasonal rate and indicated output for the first quarter is about 3% above that of the first quarter in 1949. Cold weather continuing through most of April held the demand at well above that of a year ago. Indicated demand for the first quarter is 13% greater than for the same period in 1949.

Residual Fuels—Production in April at higher than the 1949 rate is indicated and for the first quarter of 1950 indicated output is nearly 2.5% larger than for the 1949 period. The severe weather late in the winter and the coal strike brought about an increase in demand for the quarter of 11% over the 1949 demand. Indications are the increased rate of demand continued through April.

Table 1—Crude Run to Stills First Quarter of 1950, by Refinery Areas*

(Bureau of Mines Data)

Area	(1000 bbls.) First 3 Mos. 1949	First 3 Mos. 1950	% Change
East Coast	71,362	73,573	+ 3.1
Gulf Coast	161,294	151,630	— 6.0
Inland			
Appalachian	14,668	14,247	— 2.9
Ind.-Ill.-Ky.	82,807	90,324	+ 9.1
Southwest	65,853	64,175	— 2.5
Rocky Mtn.	15,124	16,765	+ 10.8
Total Inland	178,446	185,511	+ 3.9
U. S. Except Cal.	411,302	410,714	— .11
California	83,025	75,342	— 9.2
Total U. S.	494,227	486,056	— 1.7

* March, 1950, API Data

Table 2—Location of Gasoline Stocks at Refineries, by Areas

(U. S. Bureau of Mines Data)

Area	(1000 bbls) April 1, 1949	April 1,* 1950	% Change
East Coast	27,501	26,680	— 2.9
Gulf Coast	25,185	28,500	+ 13.2
Inland			
Appalachian	3,918	3,735	— 4.9
Ind.-Ill.-Ky.	29,077	28,900	— 0.6
Southwest	21,632	21,980	+ 1.6
Rocky Mtn.	4,212	5,350	+ 27.0
Total Inland	58,839	59,965	+ 1.9
U. S. Except Cal.	111,525	115,175	+ 3.3
California	15,918	20,380	+ 28.0
Total U. S.	127,443	135,555	+ 6.4

* API Data

Crude Runs to Stills

Daily Average (1000 Bbls.)

	Domestic	Foreign	TOTAL
April '50 API*	4,770	425	5,195
April '49 BM	4,776	365	5,141
Change	— 6	+ 60	+ 55
% Change	0.1	16.4	1.1

* Through April 22.

Total (1,000 Bbls.)
(Bureau of Mines Data)

3 Mo. '50*	443,922	42,134	486,056
3 Mo. '49	457,714	36,513	494,227
Change	—13,792	+ 5,611	—8,171
% Change	3.0	15.3	1.7

* March from API data.

Yields on Crude Runs to Stills

	Gasoline %	Kerosine %	Dist. Fuels %	Resid. Fuels %
April '50 API	42.3	5.6	18.8	21.3
March '50 API	42.8	6.1	17.7	21.6
Feb. '50 BM	42.7	6.3	19.0	21.7
April '49 BM	40.1	5.2	16.3	23.2

Fig. 1, Runs to Stills—Show Effect of Plant Strikes

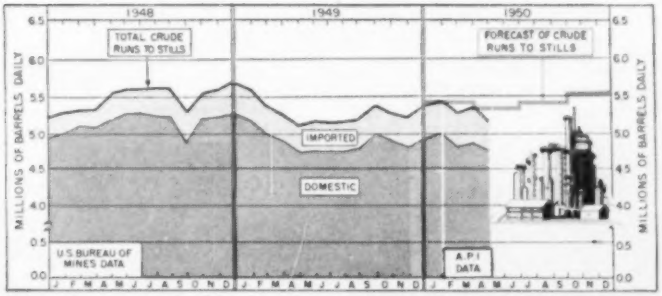
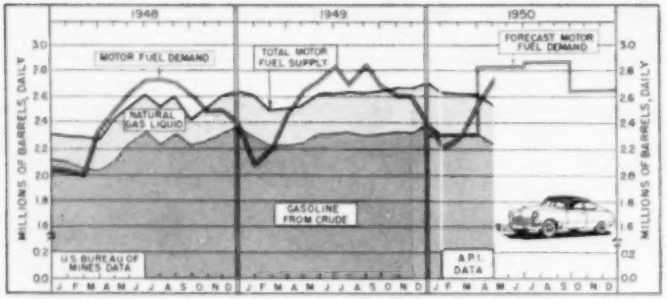


Fig. 2, Motor Fuel—April Output Close to '49 Rate


1948
1949
1950
MOTOR FUEL DEMAND
TOTAL MOTOR FUEL SUPPLY
FORECAST MOTOR FUEL DEMAND
NATURAL GAS LIQUID
GASOLINE FROM CRUDE
U.S. BUREAU OF MINES DATA
API DATA
MILLIONS OF BARRELS, DAILY
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D

Natural Gas Liquids include natural gasoline blended at refineries, and used direct as motor fuel.

Fig. 3, Gasoline Stocks—Seasonal Decline Under Way

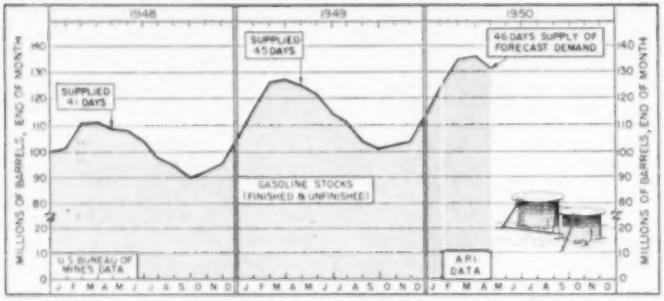

1948
1949
1950
SUPPLIED 41 DAYS
SUPPLIED 45 DAYS
46 DAYS SUPPLY OF FORECAST DEMAND
GASOLINE STOCKS (FINISHED & UNFINISHED)
U.S. BUREAU OF MINES DATA
API DATA
MILLIONS OF BARRELS, END OF MONTH
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D

Fig. 4, Heating Oils—Demand Holds Up Through April

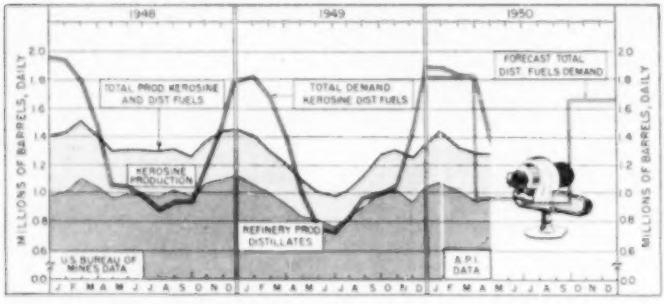
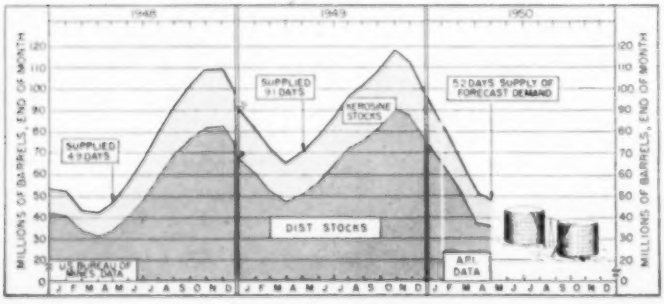

1948
1949
1950
TOTAL PROD. KEROSINE AND DIST FUELS
TOTAL DEMAND KEROSINE DIST FUELS
FORECAST TOTAL DIST. FUELS DEMAND
KEROSINE PRODUCTION
REFINERY PROD. DISTILLATES
U.S. BUREAU OF MINES DATA
API DATA
MILLIONS OF BARRELS, DAILY
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D

Fig. 5, Heating Oil Stocks—Reduced in April


1948
1949
1950
SUPPLIED 49 DAYS
SUPPLIED 91 DAYS
52 DAYS SUPPLY OF FORECAST DEMAND
KEROSINE STOCKS
DIST. STOCKS
U.S. BUREAU OF MINES DATA
API DATA
MILLIONS OF BARRELS, END OF MONTH
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D

* Change in reporting in California eliminated 4,900,000 bbls. from distillate classification.

Motor Fuel Supply

Daily Average (1000 bbls.)

	Gasoline from Crude	Natural Blended Used Direct	TOTAL
April '50 API*	2,255	320	2,575
April '49 BM	2,282	290	2,572
Change	-27	+30	+3
% Change	1.2	10.3	.01

* Through April 22.

Total (1,000 bbls.)
(Bureau of Mines Data)

3 Mo. '50*	209,164	28,163	237,327
3 Mo. '49	205,598	25,643	231,041
Change	+3,566	+2,520	+6,286
% Change	1.8	9.8	2.7

* March from API data.

Motor Fuel Demand Including Exports

Daily Average (1000 bbls.)

April '50 API*	2,770
April '49 BM	2,617
Change	+153
% Change	5.8

*Through April 22.

Total (1000 bbls.)
(Bureau of Mines Data)

3 Mo. '50*	215,922
3 Mo. '49	206,132
Change	+9,790
% Change	4.8

* March from API data.

Gasoline Stocks

Finished and unfinished, end of month (1000 bbls.)

April '50 API*	131,360
March '50 API	135,560
Feb. '50 BM	132,796
April '49 BM	125,351

* On April 22.

Heating Oils Production

(Kerosine and Distillates)
Daily Average (1000 bbls.)

	Kerosine	Dist. Fuels	TOTAL
April '50 API*	290	980	1,270
April '49 BM	272	846	1,118
Change	+18	+134	+152
% Change	6.6	15.8	13.6

* Through April 22.

Total (1000 bbls.)
(Bureau of Mines Data)

3 Mo. '50*	30,733	90,969	121,702
3 Mo. '49	28,301	89,975	118,276
Change	+2,432	+994	+3,426
% Change	8.6	1.1	2.9

* March 1950 from API data.

Heating Oils Demand

Daily Average (1000 bbls.)

	Kerosine	Dist. Fuels	TOTAL
April '50 API*	294	1,053	1,347
April '49 BM	230	777	1,007
Change	+64	+276	+340
% Change	27.8	35.5	33.7

* Through April 22.

Total (1000 bbls.)
(Bureau of Mines Data)

3 Mo. '50*	39,349	127,801	167,150
3 Mo. '49	34,404	113,462	147,866
Change	+4,945	+14,339	+19,284
% Change	14.4	12.6	13.0

*March 1950 from API data.

Heating Oil Stocks

(1000 bbls. end of month)

	Kerosine	Dist. Fuels	TOTAL
April '50 API*	12,653	37,121	49,554
March '50 API	12,500	39,754	51,554
Feb. '50 BM	16,126	52,206	68,332
April '49 BM	19,052	51,231	70,283

* April 22.

Fig. 6, Residuals—Demand Continues Strong

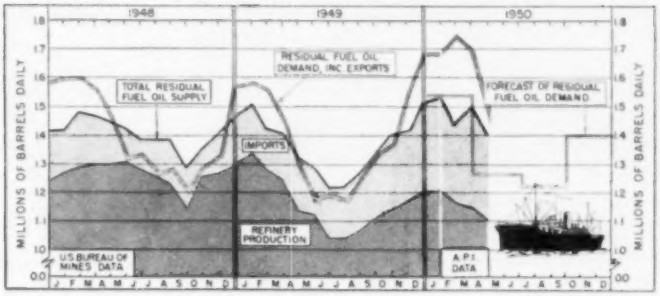
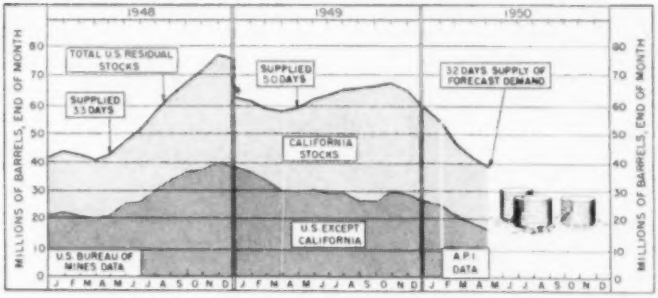


Fig. 7, Residual Stocks—Trend Downward in April



* Change in reporting in California eliminated 13,000,000 bbls. from residual classification.

Residual Fuels Production

Daily Average (1000 bbls.)

	Refinery Output	Imports	TOTAL
April '50 API*	1,100	300	1,400
April '49 BM	1,147	187	1,334
Change	−47	+113	+66
% Change	4.1	60.4	4.9

* Through April 22.

Total (1000 bbls.)
(Bureau of Mines Data)

3 Mo. '50*	106,148	28,038	134,186
3 Mo. '49	116,678	14,366	131,044
Change	−10,530	+13,672	+3,142
% Change	9.2	95.2	2.4

* March 1950 from API data.

Residual Fuels Demand

Daily Average (1000 bbls.)

April '50 API*	1,467
April '49 BM	1,299
Change	+168
% Change	12.8

* Through April 22.

Total Demand (1000 bbls.)

3 Mo. '50*	153,897
3 Mo. '49	138,390
Change	+15,507
% Change	11.2

* March 1950 from API data.

Residual Fuels Stocks

1000 bbls. end of month

	U. S. Except California	Total U. S.
April '50 API*	18,770	39,767
March '50 API	18,570	41,256
Feb. '50 BM	22,034	47,828
April '49 BM	30,046	50,028

* April 22.

Fig. 8, Production and Demand of Natural Gas Liquids

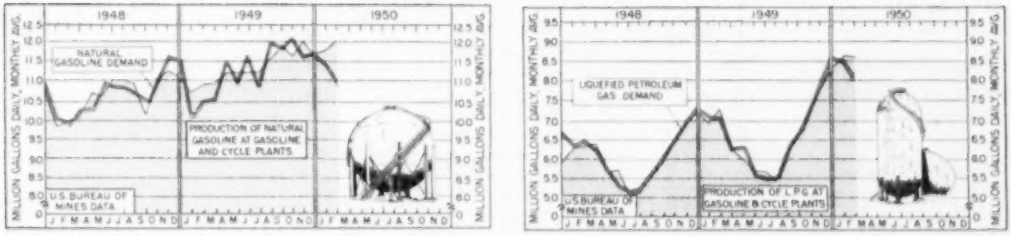
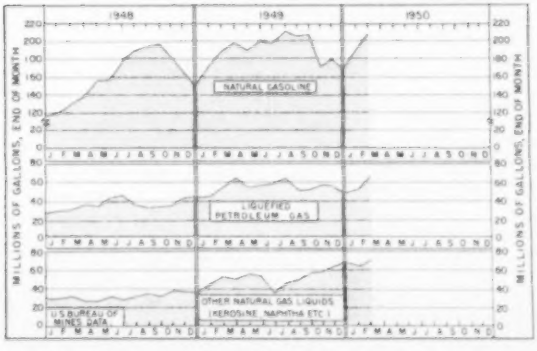

1948
1949
1950
MILLION GALLONS DAILY, MONTHLY AVG.
NATURAL GASOLINE DEMAND
PRODUCTION OF NATURAL GASOLINE AT GASOLINE AND CYCLE PLANTS
LIQUEFIED PETROLEUM GAS DEMAND
PRODUCTION OF L.P.G. AT GASOLINE & CYCLE PLANTS
U.S. BUREAU OF MINES DATA
J F M A M J J A S O N D

Fig. 9, Stocks of Natural Gas Liquids


1948
1949
1950
MILLIONS OF GALLONS, END OF MONTH
NATURAL GASOLINE
LIQUEFIED PETROLEUM GAS
OTHER NATURAL GAS LIQUIDS (KEROSINE, NAPHTHA ETC.)
U.S. BUREAU OF MINES DATA
J F M A M J J A S O N D

Natural Gas Liquids Statistics

(Source: U. S. Bureau of Mines Report on Natural Gasoline and Cycle Plant Operations)

	Production (1000 gal/day avg.) Natural Gasoline	LPG**	TOTAL	Demand* (1000 gal/day avg.) Natural Gasoline	LPG	TOTAL
Feb. '50	12,160	8,021	20,605	11,087	8,173	19,196
Feb. '49	10,800	7,300	18,100	10,550	7,060	17,610
Change	+1,360	+721	+2,505	+473	+1,113	+1,586
% Change	12.7	10.7	14.5	4.5	15.7	9.0

Total Production (1000 gal)

				Total Demand (1000 gal)		
2 Mo. '50	708,080	505,186	1,213,257	663,220	494,622	1,157,842
2 Mo. '49	635,054	417,135	1,052,389	613,009	415,384	1,028,393
Change	+73,035	+87,935	+160,868	+50,211	+79,238	+129,449
% Change	11.5	21.0	15.3	8.2	19.1	12.6

Stocks, End of Month (1000 gal)

	By Type of Product: Natural Gasoline	LPG	Other Products†	By Location: Refinery	Gasoline Plants	TOTAL
Feb. '50	209,510	66,692	71,522	92,572	254,142	346,714
Jan. '50	191,117	53,183	64,929	85,914	223,275	309,240
Feb. '49	185,377	55,952	53,842	76,692	218,479	295,171

* Demand, including exports but not transfers, is supplied from receipts from outside sources as well as current production and stock changes. Outside receipts totaled 9,700,000 gals. in February.

** Does not include LPG produced at refineries which in February totaled 81,528,000 gals.

† Includes kerosine, naphtha, specialty and other products.

ADVERTISERS' INDEX

FOR INFORMATION ON ANY PRODUCT OR SERVICE ADVERTISED IN THIS ISSUE SEE INSTRUCTIONS BELOW

Each advertiser listed in this index has been assigned a code letter for use by the reader in securing additional information about advertised products or services which interest him. This code letter appears in parentheses to the left of the advertiser's name.

Circle the code letter on the "Advertised Product Inquiry" card (on the page opposite) which corresponds to that assigned the advertiser about whose product you want further information.

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(B) ALUMINUM CO. OF AMERICA . . 527
(C) ARCO CO., THE 460
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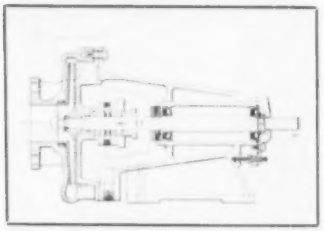
What's New!

EQUIPMENT . . . MATERIALS . . . PROCESSES . . . LITERATURE

Reviewed by WILLIAM C. UHL, Equipment Editor

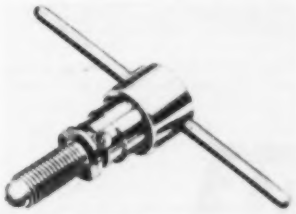
Maintenance Advantages Are Offered In Line of General Service Pumps



A number of operating and maintenance advantages are claimed for the new De Laval Type CP Centrifugal Pumps, designed for general service applications in the process industries requiring handling hot or cold clear liquids, viscous liquids, corrosives, or liquids carrying suspended solids. For example: to compensate for wear at the impeller face, the entire rotor can be adjusted axially by an external adjusting screw. Eductor vanes on back of the impeller reduce end thrust, relieve stuffing box pressure, and keep the back of the impeller clean when handling liquids with solids in suspension. Should service requirements change, the pumps can be converted from open to closed impeller or vice versa. The gland face is pre-machined and drilled for conversion from conventional packing to mechanical seals. Parts are standardized so that only two sizes of shafts, shaft locknuts, bearings, bearing cartridges, and pedestals are needed for seven different pump sizes. De Laval Steam Turbine Co.

Check No. **1** *on Reply Card*

Automatic Piston Operation Protects Pressure Bolt against Unsafe Removal



The "Wilson-Dunton" Safety Release Pressure Bolt is said to provide a necessary safety factor in oil burners, strainers, and for securing covers of many types of pressure vessels against unsafe opening. It is actuated by the pressure within the vessel. A hole through the bolt body conducts fluid under pressure to a piston within the bolt head and causes the handle-bar to be moved and held out of bolt-turning position. While under pressure, the handle will freely rotate without imparting turning movement to the bolt proper. When the pressure is released, the handle returns automatically to bolt-turning position. Thomas C. Wilson, Inc.

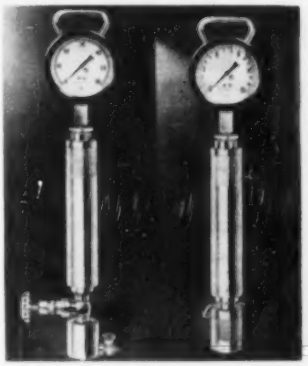
Check No. **2** *on Reply Card*

Vertical Centrifugal Meets Needs Of Limited Net Positive Suction Head

Designed to meet the need for a pump where NPSH (net positive suction head) is limited or where installation space is limited in the new, encased, close-coupled, multi-stage, vertical centrifugal "Hydro-Line" pump. Ideal applications cited are pumping of hydrocarbons such as gasoline, liquefied petroleum gases, hot or cold water, acids, bases, mild or concentrated salt solutions at temperatures from normal to 400° F. Capacities up to 5000 gpm. are obtained: maximum head is 1500 ft. All types of drives are available including electric hollow or solid shaft motors, geared right angle drive, V- or flat-belt pulley, and steam turbine. Standard materials of construction include cast iron bowls, bronze impellers and Type 416 stainless steel shafting, and special materials where required by unusual service conditions. Peerless Pump Division, Food Machinery and Chemical Corp.

Check No. **3** *on Reply Card*

Reid Vapor Pressure Bombs Designed For Avgas under new ASTM Method

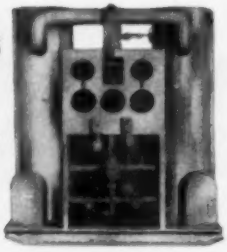


Light-weight Reid Vapor Pressure Bombs have been developed suitable for testing aviation gasoline according to the revised ASTM Method D-353-49. The bombs are also suitable for ordinary gasoline, benzol blends, and other volatile liquids. The volume ratio of air to gas chambers had been held within the close limits set for testing aviation fuels. "Precision" RVP bombs manufactured under the

For More Information

Use one of the attached reply cards to request additional details or literature on any items reviewed in "What's New!" Just circle the numbers corresponding to the numbers at the end of each item in which you are interested. Then fill in the rest of the card and drop it in the mail. No postage required.

Pritchard's *New* **HYDRYER***



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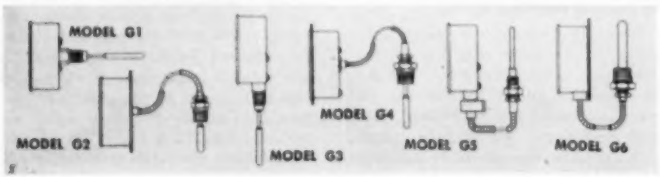

What's New!

old ASTM D-325-43 are not interchangeable with the new bombs. For improved sealing, the threads on the gage and bomb openings were changed from the previous model. Without the pressure gage, the immersion sampling bomb weighs three lbs., the pressure sampling bomb weighs 4½ lbs. Bourdon-type Reid gages are guaranteed accurate to within 0.5% of scale range, have a stainless steel mechanism. Precision Scientific Co.

Check No. **4** *on Reply Card*

Direct Reading pH Instrument Has High Stability, Freedom from Drift

The Coleman Model 30 AC line-operated pH meter is said to be characterized by high stability and almost complete freedom from drift. Designed for operation at 95-130 volts, 50/60 cycles, it has accuracy and reproducibility to within 0.05 pH. Continuous direct reading in pH or millivolts, the instrument has polarizing current available for Karl Fischer titrations. Coleman Instruments Inc.

Check No. **5** *on Reply Card*

Impervious Graphite Valves Designed For Corrosives Free from Abrasives

A newly-designed "Karbate" impervious graphite globe valve, in 1 and 2-in. sizes, is recommended for shut-off and throttling service with corrosive fluids free from abrasive solids. Except for the Teflon packing, all valve parts in contact with the fluid are Karbate material, resistant to hydrochloric, dilute sulfuric and hydrofluoric acids, and chlorinated organic compounds, as well as to thermal shock. Because of the high thermal conductivity of impervious graphite the valve may be readily heated from a steam coil of copper tubing wrapped around it, for handling highly viscous or saturated solutions. National Carbon Div., Union Carbide and Carbon Corp.

Check No. **6** *on Reply Card*

industrial
OIL AND GAS BURNING EQUIPMENT

- Mechanical Atomizing Oil Burners
- Steam Atomizing Oil Burners
- Refractory Burner and Muffle Blocks
- Industrial Gas Burners
- Low Air Pressure Oil Burners
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- Tandem Block Combustion Units
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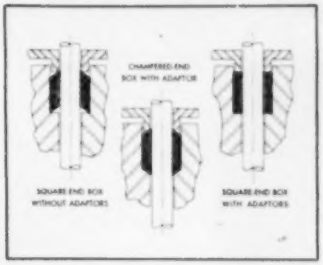
What's New!

Cone-type Teflon Packing Gives High Chemical Resistance and Low Friction

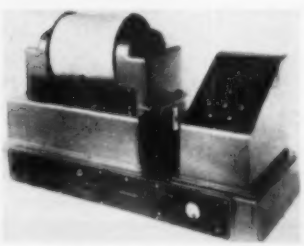


A Cone-type "Teflon" packing has been developed for use in stuffing boxes where the application demands complete resistance to chemical attack and where the packing must allow a freely operating spindle. Called "Chemiseal No. 810C", the packing is formed entirely of Teflon and is completely inert to all chemical action at temperatures from −150 to 550° F. It is supplied as a series of cone-shaped rings in which the sealing action is derived partly from the flexing of the cones and does not depend entirely on deformation. Because less pressure is needed to cause the flexing, than is required to deform a conventional packing, low gland pressure is sufficient to maintain a seal yet create minimum friction, thus allowing free spindle operation. The packing is supplied in sets to meet specified requirements, and is available with adaptors for either square-end or chamfered-end stuffing boxes. If necessary, the cone-shaped rings may be split for installation. United States Gasket Co.

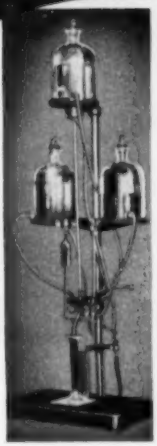
Check No. 7 on Reply Card

Infrared Spectrophotometer Provides Wider Range of Operating Variables

A double beam infrared spectrophotometer with a wider range of operating variables than earlier commercial models is now in production. The Model 21 records directly in per cent transmission against a linear wavelength scale on large charts.



SULFUR and CARBON *Analyses* in PETROLEUM PRODUCTS



The sulfur content of oils, waxes and greases is an important measure of the value and quality of the product.

Whether the desired sulfur content be high or low, it is necessary to know exactly what amount is present.

The combustion method offers a rapid and sure means of determining sulfur in the wide range of percentages and materials encountered in the oil and grease field.

The Dietert-Detroit Sulfur Determinator embodies the correct principles of the combustion method in a simple, rugged and convenient form. Complete analysis can be made in less than five minutes.

Carbon determinations on organic compounds are being made in as little as two minutes with the Dietert-Detroit No. 300-S Carbon Determinator.

This method can be applied to any petroleum product. One example of the usefulness of this method is the analysis of cracking catalyst for carbon content.

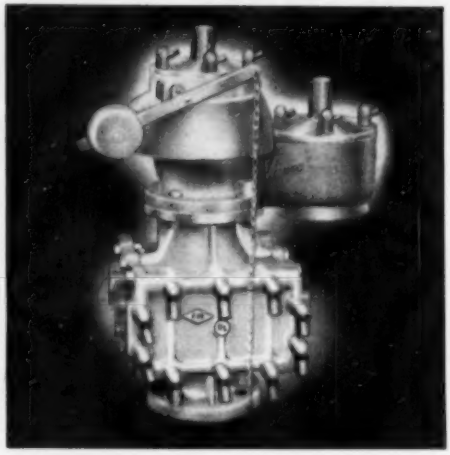
Leading oil companies* are taking advantage of these versatile, time-saving determinators. Write to Dept. P-3 for detailed information on how you can apply rapid carbon and sulfur analysis to your problems.

*Two typical users— THE SHELL OIL COMPANY, THE PURE OIL COMPANY

CONTROL EQUIPMENT
HARRY W. DIETERT COMPANY
9330 ROSELAWN • DETROIT 4, MICH.

[To obtain more data on advertised products see page 536]

TANK VENTING ECONOMICS



"VAREC" Figure No. 5800A Conservation Vent Unit—consists of Figure No. 2000A Conservation Vent Valve and Figure No. 50 Flame Arrester

. . . how much does it flow?

Compare vent valves on a basis of flow and you may find that a smaller valve or even a single valve instead of two has sufficient capacity to do your job. Even if the same size is required, *the valve with most flow capacity gives you the greatest tank protection.*

With flow capacity so vital in vent valve selection, either the "VAREC" Figure No. 2000 Series Conservation Vent Valves or the "VAREC" Figure No. 5800 Series Vent Units are your most economical buy. The flow path through the Figure No. 2000 Valve is similar to that of a high-gas-velocity turbine nozzle. As a result, this valve, mounted on a nipple, not only flows more than the nipple alone, but flows more than the nipples could theoretically flow alone.

Flow through all vent units is governed by the flame arresters. "VAREC" Figure No. 50 Flame Arresters have largest net free area and permit highest flow with required safety against flame propagation. They are listed by Underwriters' Laboratories and approved by Associated Factory Mutuals Laboratories and other governing agencies.

Certified flow curves are available for all sizes of "VAREC" Vent Valves and Units. Compare these and demand "VAREC" Tank Venting Equipment on your tanks for the best in safety and economy.

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CP-18

THE VAPOR RECOVERY SYSTEMS COMPANY

COMPTON, CALIFORNIA, U. S. A.

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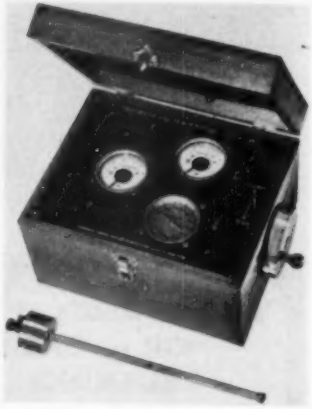
What's New!

The instrument's resolution is up to the limitations imposed by the Raleigh criterion and Johnson noise. Its speed of scanning ranges from 3 min. to 100 hrs. for the rock salt region. Wavelength drive speed can be suppressed automatically when desired. Time of response varies from a few seconds to more than a minute for full scale deflections. Overall range is from under 2 microns to 15 microns in the rock salt region. Chart scales are uniform from 1 to 50 in. per micron by integral factors. Chart size is about 32 x 11 in. Perkin-Elmer Corp.

Check No. **8** *on Reply Card*

Readings through 5000 F. Obtained By New Gas Temperature Indicator

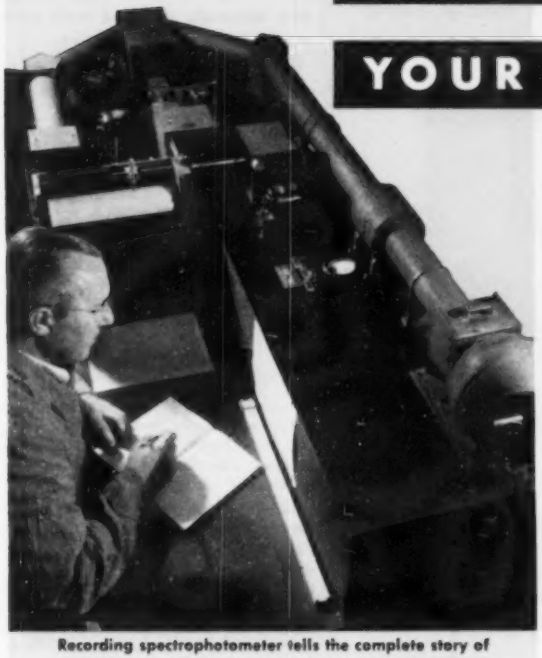


The Fairchild Model 263 Gas Temperature Indicator is a remote reading instrument providing accurate measurements at up to and more than 5,000° F. The operating principle is based on established equations for gas flow through a metering orifice. In operation, a small sample of the gases is obtained by means of a water-cooled stainless steel probe, which may be manipulated to obtain a temperature traverse of the gas stream. The sample is immediately passed through a small iridium orifice, cooled, and passed through a second metering orifice and manually operated pressure reducing valve to atmosphere. By adjustment, the differential pressure drop across the iridium orifice will be a linear function of the absolute temperature of the gases being measured. A differential pressure gage connected across this orifice then indicates the gas temperature. Fairchild Camera & Instrument Corp.

Check No. **9** *on Reply Card*

COLOR-IDENTIFY YOUR GASOLINE...

from the complete line of Du Pont Gasoline Dyes



Recording spectrophotometer tells the complete story of a color—its strength, shade and brightness—in writing. It is used to standardize Du Pont Gasoline Dyes, assuring the refiner of uniform tinctorial properties.

Du Pont Gasoline Dyes have been developed to meet the demands of the Petroleum Industry for dependably uniform colors, and are today accepted as standard.

Possessing high tinctorial strength and good solubility, the four Du Pont Gasoline Dyes may be used independently, or mixed, to obtain virtually any shade or color desired.

Du Pont District Laboratories, conveniently located throughout the country, will be glad to make recommendations as to the mixture and quantity of each dye needed to arrive at the color you desire. They will also work with your laboratory on other additive recommendations. Write or call your nearest Du Pont District Office. Ask for samples.

APPROXIMATE SOLUBILITY OF DU PONT GASOLINE DYES
at 60° F.—Grams/Gal.

	Oil Yellow N	Oil Orange	Oil Red	Oil Blue A*
Straight Run Gasoline	27	24	12	8
Aviation Gasoline	24	25	6	7
Thermal-Cracked Gasoline	42	44	13	13
Catalytic-Cracked Gasoline	72	66	23	12
Benzene	832	242	114	300

*Du Pont Oil Blue A is the new, high tinctorial strength blue gasoline dye, 35% stronger than the previous Du Pont Oil Blue and several times more soluble. Meets requirements of Specification MIL-F-5572 and may be used in aviation gasolines intended for military use.

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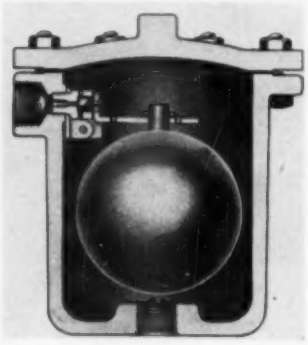
specify PRECISION, to be sure

What's New!

Disc Is Replaced by Ball-type Seat in New Automatic Vent and Drain Valve



Use of a simplified ball-type seating mechanism instead of the customary disc has provided for improvement of the Crane automatic vent and drain valve to assure more accurate seating and longer life. The valve is used in water or oil systems to remove entrapped air, or in compressed air systems to remove water and oil. A complete range of sizes is available to handle all air requirements up to 150 psi. and water to 125 psi. Body and cap are of cast iron, the float is copper. The ball seat is "Exelloy" and the ball is of hardened stainless steel. Crane Co.

Check No. **10** *on Reply Card*

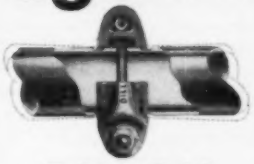
Labyrinth Shaft Seals Enable Turbine To Produce 1450 psig. in One Stage

The De Laval "CP" Turbine is said to be the first standard single stage turbine designed especially for high pressure service. Initial pressures up to 1450 psig., initial temperatures to 950° F., and back pressures to 300 psig. can be handled in three sizes for capacities to 2000 hp. The unit contains all labyrinth shaft seals, which consist of a series of shaft grooves and mating tongues of stainless steel packing. The number of labyrinths depends on the exhaust pressure rating—as many as 52 labyrinths per side being employed for the highest pressures. This type seal prevents leakage, reduces losses, lasts longer and requires less maintenance, it is stated. By supporting the turbine on the true centerline with the front end on a flexible channel, both radial and axial expansion from high temperatures can take place without disturbing the shaft centerline. De Laval Steam Turbine Co.

Check No. **11** *on Reply Card*

[*To obtain more data on advertised products see page* 536]

back again..



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WEDGEPLUG
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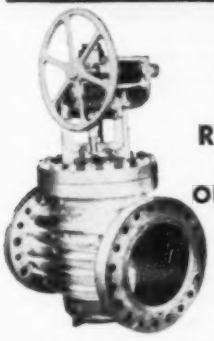

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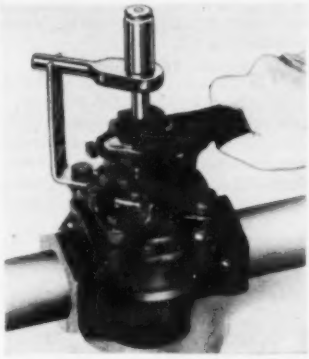
Wedgeplug Valve Co., Inc.
Department "P"
New Orleans 15, U.S.A.

What's New!

Plug Valve Lubrication Time Cut 90% Or More by Simple Automatic Device



The Delta Automatic Plug Valve Lubricator will handle any lubricated plug valve from ½ to 20-in. in size. It forces a measured amount of lubricant into the channels of the valve each time it is opened or closed. Composed of three stainless steel parts, it can be attached without making any alterations on the valve. The valve can be opened and closed between 50 and 100 times before the reservoir must be refilled. Refilling is accomplished with a Delta Lubricant Gun which snap-fits the top of the lubricator. Manufacturer states an operator can usually service and lubricate 10 to 15 valves equipped with the unit in the same amount of time required to lubricate one valve one time in the conventional manner. Delta Engrg. Sales Co.

Check No. **12** *on Reply Card*

Trade Literature

Caustic Soda

Mathieson Caustic Soda, a 48-page book covering all phases connected with the manufacture, economics, properties, handling, and application of this product. Mathieson Chemical Corp.

Check No. **13** *on Reply Card*

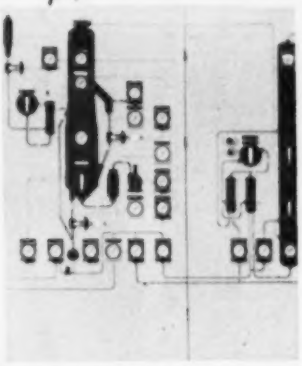
Process Furnaces

Petro-Chem Iso-Flow Furnaces, Bulletin 50-1; describes and illustrates the Radiant Convection Design, Type D-107, including significant design and operating characteristics: *Petro-Chem Iso-Flow Steam Generators*, Bulletin 50-2; contains detailed summary of design and operating characteristics and operating test data on a 30,000 lb./hr. installation. Petro-Chem Development Co., Inc.

Check No. **14** *on Reply Card*

PANELGRAPHS

To fit your processes... Completely assembled, piped and wired



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With Panelgraphs for your refinery units, operators visualize an entire process — or entire refinery — at a glance. Facsimile flow lines and equipment have their control instruments right on them . . . Minimizing chances of mis-reading identification plates . . . Making control simpler, faster, more positive.

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Panellit builds conventional panels, cubicles and consoles to meet most exacting specifications; either supplying instruments or building equipment to fit your instruments. Full details sent promptly upon request.

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Refractory Materials

Lumnite Refractory Concrete has been revised and reprinted with latest data and information on this calcium-aluminate cement for high temperature service. Lumnite Division, Universal Atlas Cement Co.

Check No. **15** *on Reply Card*

Water Clarifiers and Softeners

Graver Reactivator for Rapid Economical Water Clarification and Softening, Bulletin WC-103; describes design, operation, and features of this type unit and its accessories, including an introduction explaining the principles and chemistry of cold process water treatment. Graver Water Conditioning Co.

Check No. **16** *on Reply Card*

Refinery Process Pumps

Cradle-Mounted Centrifugal Pumps for Process and Refinery Service, Form 7212; a four-page folder introducing a new line of pumps, known as Class CRVR, in sizes 1, 1½, 2, and 3-in. for capacities from 20 to 550 gpm. and total heads to 250 ft., suitable for reflux pumping and transfer service in handling propane, butane, gasoline, and other light distillates; includes dimensions and specifications. Ingersoll-Rand Co., Cameron Pump Div.

Check No. **17** *on Reply Card*

Industrial Lube Additives

"dag" Coloidal Graphite for Industrial Lubricants; a four-page pamphlet describing: (1) "Oildag" a colloidal graphite dispersion for blending in petroleum products to use in lubricating internal combustion engines, industrial machinery, etc.; (2) a concentrated dispersion of colloidal graphite in mineral spirits for high temperature lubricating problems, and (3) a concentrated dispersion in alcohol for fast drying applications. Acheson Colloids Corp.

Check No. **18** *on Reply Card*

3-in. Strip Chart Recorder

Taylor Transet Recorder, Form No. 98078; an 8-page advertising brochure, illustrates and gives some of the details of a new small-size receiver-recorder designed for saving instrument panel space. Taylor Instrument Cos.

Check No. **19** *on Reply Card*

Tar or Fuel Oil Flowmeter

Hagan Differential Pressure Transformer, Bulletin 2250: presents operating principles, specifications, and other details on an instrument said to be particularly suited for metering the flow of tar or fuel oil; its differential measuring range being 100 in. water to 25 psi., at static pressures to 300 psig. Hagan Corp.

Check No. **20** *on Reply Card*

Water Treating Processes, Equipment

Water Conditioning Processes and Equipment, Bulletin WC-100: 8 pages, outlines products, services, background of Graver Water Conditioning Co.

Check No. **21** *on Reply Card*

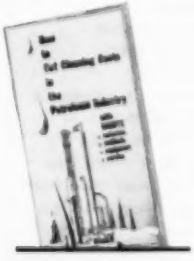
Tool Room Operation

How to Figure Your Return on an Investment in McCaskey Tool Crib Control, a four-page folder providing an answer, by a typical example, to this question. McCaskey Register Co., Industrial Division.

Check No. **22** *on Reply Card*

TANK CAR INTERIORS

cleaned faster to speed up turnaround



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WITH the Oakite Interior Tank Cleaner you can count on much greater availability of tank cars. This unit cuts tank car cleaning time 70%. It eliminates manual brushing, scraping and steaming-out. With this completely automatic cleaning unit you can condition light-oil carriers in ½ to 1 hour. Crude, creosote or asphalt carriers take from 1 to 3 hours.

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Technical Service Representatives in Principal Cities of U. S. & Canada

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SPECIALIZED INDUSTRIAL CLEANING
MATERIALS • METHODS • SERVICE

Temperature, Pressure Instruments

Ratotherm and Ratogage Temperature and Pressure Instruments, Preliminary Issue, Catalog 86; covers line of temperature instruments with thermal systems of liquid, vapor-liquid, or gas for ranges from —125 to 1000° F., and pressure instruments with bellows, multiple-diaphragm, slack-diaphragm, or helical elements for range from 30-in. Hg. to 10,000 psi., also combinations in one instrument case; includes discussion of cascade control for a fractionator, and a description of the Type 3 Pneumatrol Unit with proportional band, automatic reset, and derivative action control. Fischer & Porter Co.

Check No. **23** *on Reply Card*

Steam Plant Equipment

Yarway Steam Plant Equipment, Bulletin G-1307; a 12-page condensed catalog describing high, low, and medium pressure blow-off valves, water columns and gages, liquid level indicators and recorders, expansion joints, traps, strainers, and spray nozzles. Yarnall-Waring Co.

Check No. **24** *on Reply Card*

Stainless Weld Fittings Price List

Stainless Steel Welding Fittings, Price List 52W, April 1, 1950; covers elbows, return bends, stub ends, tees, reducers, etc. in Schedules 5, 10, 40, and 80 pipe thicknesses, in Types 304, 316, and 347 alloys. The Cooper Alloy Foundry Co.

Check No. **25** *on Reply Card*

Fatty Acids

Hardesty Fatty Acids, a 24-page catalog listing complete specifications and shipping data on line of fatty acids including stearic acid, red oil, animal, vegetable, and fish oil fatty acid, stearine pitch, and glycerine; with three data charts showing composition of fats and oils, color standards comparator, and temperature conversion tables. W. C. Hardesty Co., Inc.

Check No. **26** *on Reply Card*

Heat Exchangers, Fluid Coolers

Trane Fluid Coolers (Dry Type), Bulletin DS-395; 32-page booklet covering general information, capacities, performance curves, roughing-in dimensions, installation details, and specifications on equipment designed primarily for engine cooling but adaptable to many applications in natural gasoline plants such as overhead product condensers, steam condensers, air coolers, and the like. The Trane Co.

Check No. **27** *on Reply Card*

Industrial Chemicals

Eastman Industrial Chemicals, new 1950 Catalog with specifications, properties, and typical uses of such materials as aliphatic acids and anhydrides, alcohols, aldehydes, plasticizers and solvents; aromatic amines, aminophenols, phenols and phenol ethers; cellulose products; inorganic chemicals; and so on. Tennessee Eastman Corp.

Check No. **28** *on Reply Card*

Lithium Compounds

Lithium in Modern Industry; a 28-page booklet reviewing and forecasting significant developments in lithium chemistry since 1940, discussing the industrial applications of lithium compounds and newer uses of these ma-

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GLIDDOL

the Soybean Derivative by

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Refiners of lubricating oil find in Gliddol a soybean additive that not only checks oxidation and reduces surface tension, which promotes thorough blending of oil and additives, but one that effectively disperses insoluble solids to give oils a longer life of usefulness and to provide greater protection for motors. In grease, this superior blending agent and inhibitor serves similar ends. In leaded and unleaded gasoline Gliddol acts as a protective colloid to prevent the formation of a precipitate and retards deterioration of the gasoline on exposure to sunlight. Fuel oil treated with Gliddol R shows less precipitate after long heating and has a lighter color than untreated oil.

For further details on the advantages of Gliddol and Gliddol products as they may be related to *your* produc. . . . consult Glidden, Pacemaker in Soya Research. The complete facilities of our Technical Service Department are always at your disposal.

QUALITY Glidden PRODUCTS

The Glidden Company
SOYA PRODUCTS DIVISION
5165 W. Moffat Street
Chicago 39, Illinois

[*To obtain more data on advertised products see page* 536]

terials; including a bibliography of technical references, numerous tables and other data. Foote Mineral Co.

Check No. **29** *on Reply Card*

Safety Head Prices

BS&B Safety Head Price List; 16 pages explaining sizes, ratings specifications, and prices on safety head flanges, safety head rupture discs, safety head vacuum supports, refrigerant relief valves, pressure-vacuum vent valves, and combined bent-valve-flame arrestor units. Black, Sivalls and Bryson, Inc.

Check No. **30** *on Reply Card*

Pump Motor Selection

E-M Synchronizer, No. 30 Oil Industry Number; has for its feature article, "How to Select Large Motors for Pumping Service in the Oil Industry," covering electric motor drives for refinery, pipeline, and general service pumps. Electric Machinery Mfg. Co.

Check No. **31** *on Reply Card*

Power Plant Valves, Controls

Swartwout Pressure Regulating Valves and Pressure Master Controls, Bulletin S-22-C; 12-page booklet on complete line of low pressure regulating valves, accessories for steam plant use, including diagrams, line drawings, specifications, and selection data. The Swartwout Co.

Check No. **32** *on Reply Card*

Centrifugal Refinery Pumps

Pacific Volute Type HV Single Stage, Double Suction Impeller, Centrifugal Pumps, Bulletin 111; and *Pacific Type WB High Pressure Vertical Centrifugal Pumps,* Bulletin 115: giving specifications and dimensions of each pump, along with illustrated cross section. Pacific Pumps, Inc.

Check No. **33** *on Reply Card*

Radioactivity Supplies

Tracerlab Catalog B; 90 pages of detailed information on instruments, Geiger-Mueller tubes, tagged organic and inorganic chemicals, and industrial Beta Ray thickness gauges, including full line of equipment and supplies for radioactivity laboratories. Tracerlab, Inc.

Check No. **34** *on Reply Card*

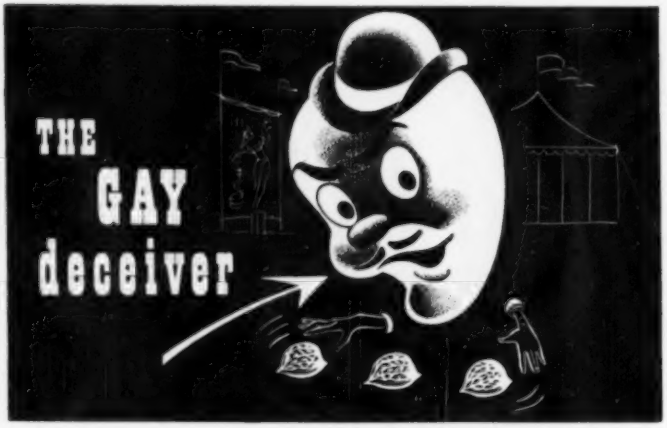
Gas Analysis

The Analysis of Gases, A Brief History and Modern Trends, is a featured article of the fall issue of the *Burrell Announcer;* giving background and major developments in this work from von Helmont in the 16th century to the present time, including recent advances such as thermal conductivity, infrared and mass spectroscopy, and fractional adsorption. Burrell Corp.

Check No. **35** *on Reply Card*

For Your Convenience

Business reply cards are included in each issue of PETROLEUM PROCESSING to assist you in obtaining more information on any items reviewed in "What's New!" You'll find them facing the first page of this section. Just circle the numbers corresponding to the numbers at the end of each item in which you are interested. Then fill in the bottom of the card and drop it in the mail. No postage required.



Don't be fooled by power-laden Btu's that escape from improperly insulated or uninsulated heated equipment. Such shenanigans represent an expensive luxury which no plant can afford.

Check power losses, cut production costs, raise efficiency. Be sure your heated equipment is protected by efficient, low-cost **CAREY Industrial Insulation!**

And here's a new product to keep Btu's on the job . . . CAREY TEMPCHEK

a specialized material with a temperature range up to 1500° F., low K factor, rugged strength, excellent "Handle-ability"—

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Ask about it!

Call your CAREY representative today. He's a trained expert who is eager to serve you.

CAREY Makes the Complete Line!

85% Magnesia—Industrial Rock Wool—Asbestos—Pipe Coverings—Sheets—Blocks—Batts—Papers—Air-Cell.

Write for your **free** copy of "Heat Insulation For Industry." Address your request to Dept. PP-5. The Philip Carey Manufacturing Company, Cincinnati 15, Ohio. In Canada: The Philip Carey Company, Ltd., 1557 MacKay Street, Montreal 25, P. Q.

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Personals

Eric W. Luster, manager of the Esso Engineering Dept. of Standard Oil Development Co., has been named vice president of the department and a member of the company's board of directors. A veteran of 34 years service with the company, including the supervision of the process engineering of wartime plants that were rushed into service for synthetic rubber, aviation gasoline and synthetic toluene, Mr. Luster succeeds **Dr. Nathaniel E. Loomis,** who has retired after 32 years service.

Mr. Luster

Mr. Luster was graduated from Rutgers University in 1914 with M.E. and E.E. degrees and joined Standard in 1916. He entered the army as a second lieutenant in 1917 and was discharged as a captain in 1919. After spending several years abroad with a company affiliate in Italy, Mr. Luster returned to the Esso Engineering Department at Bayway, N. J., in 1924 and became chief engineer in 1946. In September 1949 he was appointed manager of the Department.

* * *

Reginald N. Blaize, former manager of refineries, has been elected executive vice president of Eastern States Petroleum Co., Inc., by the company's board of directors. Mr. Blaize studied at Tulane University and Louisiana State University where he majored in chemical engineering and received his B.S. degree in 1934. His initial experience in petroleum processing and engineering was with Lion Oil Refining Co. Mr. Blaize joined Eastern States in 1940 as inspection and process engineer. In 1943 he was made assistant; plant superintendent and later chief engineer. He formed his own company in the field of professional consultant service in 1945 and returned to Eastern States in 1948 as manager of refineries.

* * *

Donald C. Stoll, group engineer of Standard Oil Co.'s (Ohio) manufacturing department has been appointed chief process engineer at the company's Lima, Ohio, refinery, replacing **J. D. Stubbs,** who has been named operations-control assistant at Lima.

Ralph G. Atkinson, former group engineer in the manufacturing department, has been selected to fill the newly formed position of chief process engineer at the company's No. 2 refinery in Cleveland.

Godfrey Ladd, in charge of the new solvent lubricating plant at Lima, has received **Gerald E. King,** group chemist, as his new technical assistant.

* * *

Richard E. Lauterbach has been named asst. manager of General Petroleum Corp.'s Torrance refinery and **Paul Sanders** has been promoted to general superintendent.

Mr. Lauterbach joined General Petroleum in 1936 as a laboratory assistant, became a chemical engineer in 1939 and a refinery engineer in 1945. Mr. Sanders, a veteran of nearly 31 years service with the company, has been refinery superintendent since 1945.

* * *

J. H. Olehy, manager of Continental Oil Co.'s engineering department at Ponca City, Okla., has been named regional manufacturing manager and will assume his duties on July 1 at the Houston headquarters. A graduate in electrical engineering from the University of Colorado, Mr. Olehy took special work at M.I.T. and joined Continental in 1927 as assistant refinery engineer. He became director of technical services in 1948 and was made manager of the general engineering department in 1949.

L. W. Vickery, regional refinery superintendent, has been named to assume Mr. Olehy's duties in the engineering department. Mr. Vickery has received degrees from Southwestern College and M.I.T., joining Continental in 1929 as a refinery draftsman. He was promoted to assistant superintendent of the Ponca City refinery in 1943 and became superintendent in 1948.

J. S. Hume, assistant superintendent of the Ponca City refinery and company employe for 25 years has been appointed director of technical services, manufacturing department.

H. R. Wall, superintendent at Lake Charles, La., will be transferred to the Ponca City refinery as assistant superintendent in charge of lubricating and light-oil divisions. Mr. Wall joined Continental in 1935.

J. M. Jones, refinery superintendent at Baltimore, has been named superintendent of the Lake Charles refinery. Mr. Jones joined the company in 1926.

* * *

Mr. Truesdell

Paul Truesdell, member of Universal Oil Products Co.'s advertising and public relations staff, has retired after 20 years with the company. Mr. Truesdell's 42-year career in journalism had its beginning in 1908 when he was hired by the *Cleveland Plain Dealer*. He joined *National Petroleum News* in 1917 and went to Universal in 1929. The Truesdells plan to move from Evanston, Ill. to Napoleon, Ohio.

* * *

Howard W. Sheldon, assistant director of Socony-Vacuum Oil Co.'s laboratories, retired April 1 after 24 years with the company. Mr. Sheldon was graduated from the University of Michigan in 1917 and joined Socony-Vacuum as an engineer at Paulsboro refinery in 1926. He was

Wilson, Hart Receive API Awards

Mr. Hart

Dr. Robert E. Wilson, Standard Oil Co. (Ind.), and **Dr. W. B. Hart,** Atlantic Refining Co., were given Certificates of Appreciation by the Division of Refining of the American Petroleum Institute May 3, during the 15th mid-year meeting of the Division in Cleveland. The certificates are given annually for outstanding work in the field of petroleum refining.

Mr. Wilson

Dr. Wilson is Chairman of the Board of Indiana Standard, and long has been one of the oil industry's leaders, especially in the field of research. Dr. Hart, an expert on disposal of refinery wastes, is superintendent of services of Atlantic Refining Co.'s Point Breeze, Philadelphia, refinery.

transferred to New York to become chief chemical engineer of the research and development department in 1929. Four years later he returned to Paulsboro as chemical engineer and in 1943 became general manager of the refinery. In 1947 he was again transferred to New York to assume his present position.

* * *

R. P. Hargis has succeeded **Sylvester Dayson**, resigned, as president of Premier Oil Refining Co. and general manager of Premier Petroleum Co.

C. R. Brown has been promoted industrial relations manager at Diamond Alkali Co.'s Painesville, Ohio, plant. From 1934 to 1943, Mr. Brown was associated with Sinclair Refining Co. at its Marcus Hook, Penn., refinery, first as assistant personnel manager and later as personnel manager. Following military service with the U. S. Navy during the war, he rejoined the Sinclair organization to assume full charge of the industrial relations department at East Chicago, Ind., refinery.

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has ideal melting point for greases and harder soaps

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TITRE.... (111.2-114.8°F) 44.0-46.0°C

Color 5¼" Lovibond Column (max.)	35 Yellow—8 Red		
Iodine Value (Wijs)	25	—	35
Free Fatty Acid (as oleic)	100	—	104%
Acid Number	199	—	206
Saponification Value	202	—	209

HARDESTY FATTY ACIDS

RED OIL • GLYCERINE • STEARIC ACID • WHITE OLEINE • HYDROGENATED FATTY ACIDS • STEAPINE PITCH • ANIMAL & VEGETABLE FATTY ACIDS • PALMITIC ACID

Lubrex 45, a product of Hardesty research, fits the demand for a polyunsaturate-free fatty acid especially designed for soap and lubricating grease manufacture. The fatty acids in Lubrex 45 are stabilized in our new hydrogenation unit, to give them a greater resistance to heat discoloration. Freedom from polyunsaturated fatty acids prevents rancidity or gum formation from excess unsaturation. No highly unsaturated acids remain to act as agents for polymerization. The melting point of Lubrex 45 has been accurately controlled to give the optimum possible degree of hardness for your precise requirements. Color and uniformity are strictly maintained. Write for details.

Send for new Hardesty 24-page Fatty Acid Specification Catalog

Established 1926

W. C. HARDESTY CO., INC.

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Factories: Dover, Ohio
Los Angeles, Calif. • Toronto, Can.

C. E. Olmsted, a vice president and director of The Texas Co., has been elected to the board of directors of the American Standards Assn.

Mr. Olmsted

Mr. Olmsted's experience in refining, transportation, marketing and production has brought him in touch with standardization of equipment in all phases of the oil industry. He started with The Texas Co. in 1919 and in 1923 resigned to become manager of the engineering, natural gasoline, pipe line and refining departments of the California Petroleum Corp. In 1928, Mr. Olmsted became vice president in charge of refining of The Texas Co. (California) when the California Petroleum Corp. joined Texaco.

* * *

Dr. Jerry McAfee, formerly a member of the chemical engineering staff at the Port Arthur refinery of Gulf Oil Corp., has assumed duties as director of the chemistry division of Gulf Research and Development Co. at Harmarville, Pa. Mr. McAfee succeeds **Eugene Ayres**, who has been appointed technical assistant to the executive vice president and director of research.

Mr. McAfee

Mr. Ayers

Dr. McAfee received his B.S. degree from the University of Texas and his Sc.D. from M.I.T. He held the national Tau Betal Pi Fellowship from 1937 to 1938, the duPont Fellowship from 1939 to 1940, and is a member of numerous scientific societies.

Mr. Ayres received his B.A. degree from Swarthmore College in 1912 and, in the ten years that followed, occupied himself with development and promotion of new industrial enterprises. He established the first American manufacture of diphenylamine, wool grease, lanolin, amorphous petroleum wax, and synthetic alcohols from petroleum. He developed and used methods of large-scale direct chlorination of petroleum hydrocarbons, of chemical dehydration of

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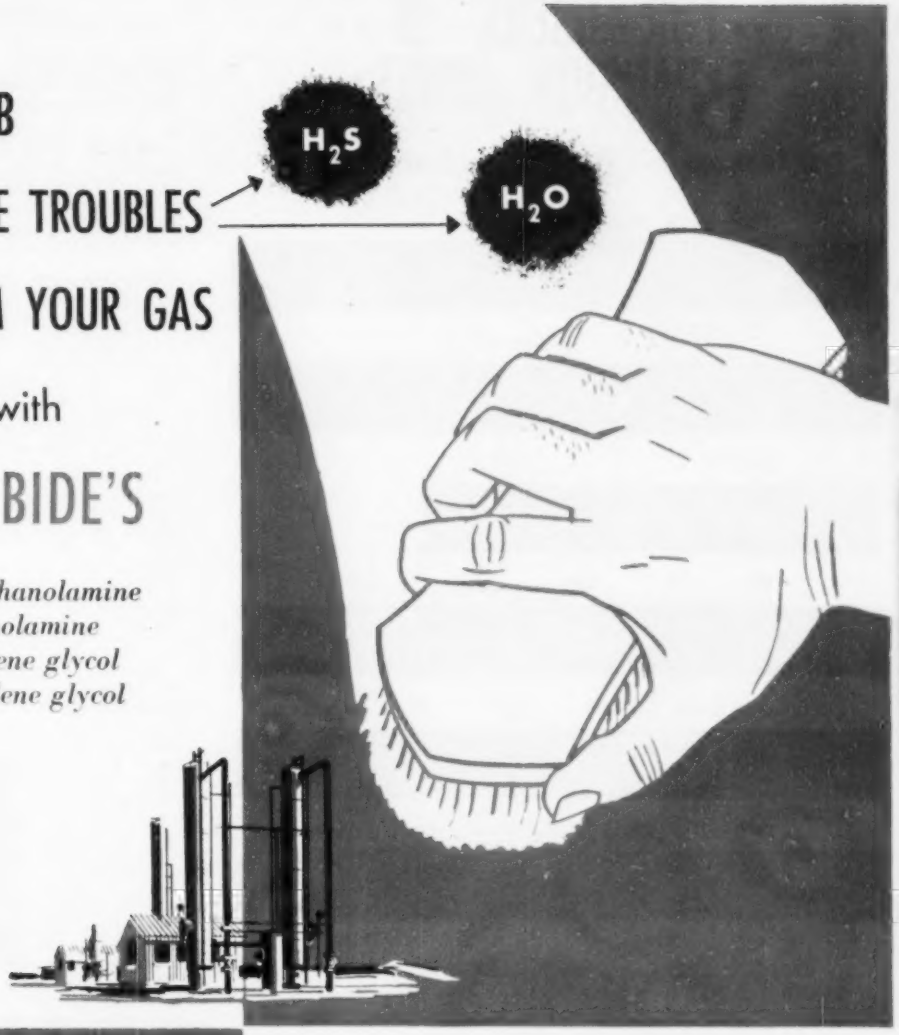
SCRUB THESE TROUBLES FROM YOUR GAS

with

CARBIDE'S

monoethanolamine
diethanolamine
diethylene glycol
triethylene glycol



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DESULFURIZE . . . and eliminate a serious trouble-maker. Monoethanolamine and diethanolamine efficiently scrub corrosive hydrogen sulfide out of natural gas and refinery gas. The hydrogen sulfide removed is a source of saleable sulfur.

DEHYDRATE with the glycols and prevent formation of pipe-clogging hydrates in high pressure transmission lines. This helps you maintain transmission line capacity and avoid valve and regulator clogging.

You can order CARBIDE's ethanolamines and glycols in tank cars, compartment tank cars, and combination drum carloads. Delivery of less than carload lots, in drums, can be made from CARBIDE warehouses in Dallas, Houston, Tulsa, Denver, Los Angeles, San Francisco, and 46 other cities throughout the country.

For gas-scrubbing chemicals that do the job, get in touch with the nearest CARBIDE office.

·· FOR · USERS · OF ·· EXPANSION JOINTS:

a lesson in simple mechanics . . .

Flex . . . metal . . . *like* . . . *this*

. . . and . . . something's . . .

bound . . . to . . . "give"

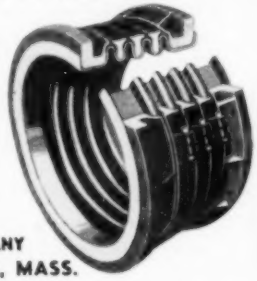
Do . . . it . . . *like* . . . *this* . . . and

. . . you . . . can . . . go . . . on . . .

***and* . . . *on* . . . *and* . . . *on* . . .**

Yes, it's a simple principle, one you know — and one you should keep in mind when buying an expansion joint. For this is, in fact, the principle underlying the all-curve construction of a Badger Directed Flexing Packless Corrugated Expansion Joint. As the illustration shows, the movement of the corrugated member of a Badger Joint is controlled and contained so that it *always follows a curved pattern* . . . no corners or angles where stresses can localize . . . no excessive strain . . . no chance of breakdown.

For economy's sake remember this important feature when you specify . . . remember that it's found *exclusively* in Badger Directed Flexing Packless Corrugated Expansion Joints.



Badger

MANUFACTURING COMPANY

230-260 BENT STREET CAMBRIDGE 41, MASS.

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crude petroleum emulsions, of refining vegetable oils, and of continuous esterification of mixed alcohols.

* * *

James H. Curtis, former manager of refineries for General Petroleum Corp., has been appointed manager of manufacturing. A graduate of the University of Michigan, he came to General Petroleum in 1942 from Lummus Co., where he had been process engineer in charge of setting up the initial operations of newly constructed petroleum refineries. Mr. Curtis became assistant manager at the 100,000 b/d Torrance refinery in 1944 and manager in 1945. He served in an advisory capacity with the Petroleum Administration for War during the war and was promoted to his former position in 1949.

Mr. Curtis

* * *

Warren L. Smith, former senior vice president of the M. W. Kellogg Co., subsidiary of Pullman, Inc., has been elected president, succeeding **Harold R. Austin,** who is retiring. Concurrently the executive staff has been enlarged with **Bennett Archambault,** former treasurer, being elected to the newly created post of vice president and general manager. The Board also named **G. Frank Bayes, Ronald B. Smith** and **Zary A. Toula** to be vice presidents.

Mr. Smith

Vice presidents **Dr. William E. Hanford, Alexander Kidd,** and **Frank Liebrecht** have been re-elected. **Daniel J. Olsen** was elected treasurer and comptroller and **Edwin L. Gidley,** secretary.

Mr. Austin joined the company 47 years ago as an engineer-salesman and rose to the presidency in 1944. He will continue to serve the needs of the company as a consultant to the president.

Joining the company in 1937, Mr. W. L. Smith was elected vice-president of the Canadian Kellogg Co., Ltd., in 1939, subsequently became vice president of the parent company in 1943, and assumed complete charge of the company's commercial activities in 1946.

Mr. Archambault joined Kellogg in

1946 after wartime service as head of the Government's Office of Scientific Research and Development in London.

Actively engaged in the construction phase of Kellogg's activities for 30 years, Mr. Bayes directed the construction of 50 major refineries and chemical projects in a span of little more than three years during the war. He was named director of construction in 1944.

Mr. R. B. Smith has been with Kellogg since 1948 as director of engineering, and is a consultant to the Atomic Energy Commission and a member of the National Advisory Committee for Aeronautics.

Mr. Toula, associated with the company for 20 years, will have his new headquarters in Paris where he will guide Kellogg's Eastern Hemisphere commercial activities.

* * *

Mr. L. O. Crockett, formerly asst. general superintendent of Gulf Oil Corp.'s refineries in Port Arthur, Sweetwater, and Fort Worth, has been transferred to the company's general offices at Pittsburgh and appointed manager of the Technical Division, of the Manufacturing Dept.

Mr. Crockett

A graduate of the University of Texas, where he continued as an instructor for several years following his graduation, Mr. Crockett joined Gulf in 1922 as asst. chemist in the experimental laboratory at Port Arthur. Six years later he was promoted to foreman of the plant used in the manufacture of Alchlor Processed oils. In 1934 he was appointed chief chemist for the three Gulf refineries in Texas.

* * *

Albert E. Miller, assistant to the vice president in charge of research and development at Sinclair Oil Co., will be honored at the annual dinner of ASTM's Committee D-2 on Petroleum Products and Lubricants in June for his work in helping to organize and serving on the Technical Committee on Aviation Fuels.

C. A. Neusbaum, assistant director of standard inspection laboratories for Standard Oil Development Co., will also be a guest of honor at the dinner. Mr. Neusbaum, a member of D-2's advisory committee, heads various committees.

J. Bennett Hill has been appointed chairman of the aircraft fuels subcommittee of the National Advisory Committee for Aeronautics. Mr. Hill is director of the chemical and engineering division of Sun Oil Co.'s research and development department.

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EDITORIAL VIEWPOINTS...

Opinions and Comments on Current Topics

The Oil Companies Can Now SELL Their Heavy-Duty Engine Oils

THE new type, heavy duty motor oils were discussed at the Lubricating Oil Panel, at the recent NPA meeting in Cleveland, in connection with the proposed revision of Army's 2-104B specifications for engine oils for severe service in ground vehicles. These are the oils which have been brought out since the war by many oil companies, primarily to meet the demands by Diesel and gasoline engine operators where higher sulfur content fuels are used. They have been variously called high-additive, high ash, Supplemental 1 and 2 oils, among others.

The new proposed military specification MIL-2104, to replace the Army's 2-104B by June of 1951, is in effect an official recognition of the new engine oils. The principal change in the standards is to the effect that the test fuel used in the engine performance test, upon which the approval of the oil depends, must be indicative of the higher-sulphur content fuels in use today in some parts of the country. To a much greater extent than ever before, performance tests are recognized as a primary requisite in determining the qualities of motor oils for heavy-duty service. The physical characteristics, which used to be the basis of specifications, give little indication of how satisfactorily oils will function under the extreme operating conditions to which both Diesel and gasoline engines may be subjected today.

Both the proposal by the Armed Services to raise their standards for heavy-duty engine oils, and the increasing dependence on engine performance tests to determine the suitability of lubricants for extreme operating conditions, pose new problems for the oil companies. It is recognized as imperative by technical authorities with some of the oil companies as well as in the Armed Services that the Military specifications for heavy-duty engine oils be revised. It is equally important that the refiners determine their ability to supply the new type oils in the volumes required, ahead of an emergency arising.

The work and cost involved for the oil companies in merely running the tests to secure the approval of their oils under the new standards is considerable. One authority has estimated running engine performance approval tests for the number of oils now on the 2-104B list would cost $8,000,000 at least. Along with this extensive test work must also go the research and development activities to further improve their oils for the increasingly severe service the Army and Navy anticipate. It is therefore most important that a high degree of cooperation be secured between the oil companies, the engine builders and the Armed Services in finalizing the new spcifications, in order that they may remain in effect for a long period. The present 2-104B specifications served their purpose well for ten years.

Raising the quality standards for heavy-duty oils for the Armed Services also brings new problems for the oil companies in supplying civilian consumers with heavy-duty engine oils. The adoption of the new specification will serve to widen the gap between the oils required by the Military, and those for most civilian heavy-duty Diesel and gasoline engine operations. In past years there has been a growing tendency for civilian users to specify 2-104B oils for the heavy-duty requirements. Under the new specification this class of users will be penalized in price when they call for MIL-2104 oils unless experience has shown such oils are actually required.

However, civilian users in the great majority of cases are not set up to make the engine performance tests required in drawing up their own specifications. The oil companies, through their own oil testing work and through their actual field experience with automotive equipment in heavy-duty service, are best suited to advise civilian consumers as to suitable oils for specific heavy-duty service. The economical operation of commercial vehicles is entirely different from the short-term service required for Military automotive equipment. Also, a great many commercial operators do not use the higher sulfur content fuels that are recognized in setting up the new engine oil standards.

The growing recognition of the new types of heavy-duty oils should encourage the oil companies to put the selling of automotive lubricants to large-scale commercial users on the same basis as they sell industrial lubricants; namely, to meet actual service requirements, rather than on arbitrary specifications set up by the consumer.

Positive Aspects of "Negative" Report

THE report of the cooperative study by oil and automotive companies and several fleet operators into the technical effects of sulfur in motor gasoline on engine operation has been referred to in some quarters as a "negative" report. Negative in the sense that conclusive data were not obtained as to the influence of fuels with up to 0.3% sulfur on engine wear, as compared with gasolines with less than 0.1% sulfur. However, the report is of value in showing that there apparently is no general direct relationship between engine wear and sulfur in fuels. The test data obtained show that the influence of up to 0.3% sulfur in gasoline may vary from a pronounced effect on cylinder and ring wear, under some operating conditions, to no effect under continuous operation at normal engine temperature. The report also provides a basis for further studies by individual engine manufacturers and oil companies.

There are also positive aspects to the CRC sponsored study in other directions. It is a striking example of cooperation between companies, petroleum and automotive, which are highly competitive; and between two industries in which some elements of competition are to be found. Oil companies, automobile and bus and truck manufacturers, and fleet operators joined forces in a program covering 4.5 years. Seven fleets, with a total of 62 vehicles participated. Over 1,500,000 test miles were accumulated, at a minimum cost. If a privately sponsored research project on this scale were feasible, the cost would amount to several millions.

A brief article giving some highlights of the report appears in this issue of PETROLEUM PROCESSING, pg. 494. The complete report, 119 pages, can be secured from the Society of Automotive Engineers for $4.00 a copy $2.00 to SAE members), under the prosaic title "Sulfur in Motor Gasoline, January, 1950."

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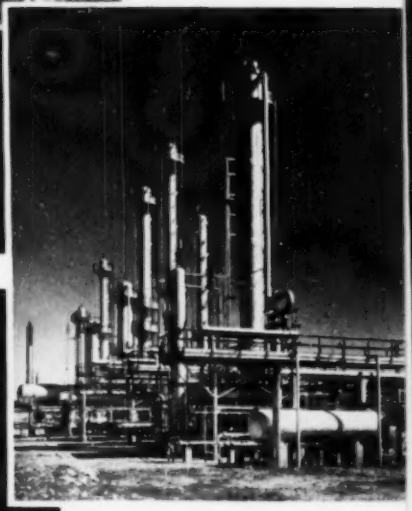

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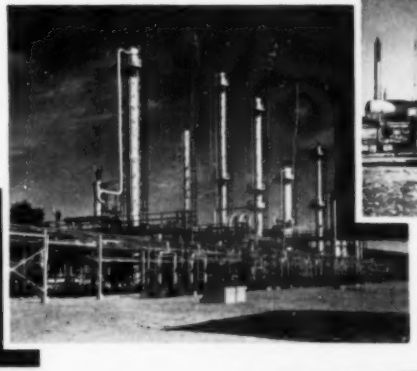

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